PRINCIPLES OF EDUCATIONAL WOODWORK

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PRINCIPLES OF
EDUCATIONAL WOODWORK

A HANDBOOK FOR TEACHERS AND
OTHERS INTERESTED IN EDUCATION

BY

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PREFACE

It has been our aim in this book to deal with the teaching and psychological aspects of Educational Woodwork, rather than with the practical details of tool manipulation. A consideration of child nature, and the ways by which the minds of the pupils may best be guided and influenced during the woodwork lessons, are set forth in a manner which it is hoped may help not only the inexperienced, but be suggestive to both certificated and technically trained teachers of riper experience.

Owing to the practical nature of handwork it is not always realised that Manual Training teachers must be as well equipped on the pedagogical side as the teachers of other subjects. The result is that the intelligence of the pupils is often not exercised and stimulated in the handicraft room to anything like the extent it should be. When all has been said as to the importance of self-activity and the acquirement of skill—and we by no means desire to minimise these—it yet remains that the cultivation of the intelligence, of active and resourceful brains, forms the *chief* claim of handwork to a place in school-work.

In addition to the chapters on Methods of Teaching a large number of working drawings of objects suitable for making in the handicraft room are given, and the principles of drawing fully explained. Much material for Observation Lessons will also be found in the book.

Candidates for the various Manual Training examinations for teachers will find no "examination hints" in this volume; but we trust they will find something better—a wider outlook that includes these lesser ends.

We have laid under contribution many books of diverse kinds, and where possible have made acknowledgment in the text. The more helpful of these sources are included in the list of books given in the chapter devoted to the teacher's reading.

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R. E. M.

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THE PRINCIPLES OF EDUCATIONAL WOODWORK

CHAPTER I

THE AIM AND SCOPE OF MANUAL TRAINING IN EDUCATION

THE influence of handwork on the development of the brain has become an educational truism. Yet it may still be said that there is rarely any Manual Training in our schools from the time children leave the Infants' school—where it rightly plays an important part—till at eleven or twelve years of age, the boys take up woodwork, and the girls cookery or laundry. If the method of "learning by doing" is beneficial in the kindergarten period, and again in the last two or three years of elementary schooling, surely it is good also for the period in between. Handwork furnishes a direct appeal to the child's desire to make things; it vitalises school-work by bringing it into closer touch with everyday interests, and affords capital training not only of the hands but of the attention and judgment.

The value of this means of education is more fully realised in America than it is here. Among the many forms of Manual Training taken there may be mentioned —paper folding and cutting, making of paper models, claywork, simple weaving, raffia-work, basketry, sewing, stringwork, cardboard construction, and knifework in thin wood. These are generally taught by the class teacher, but sometimes a special teacher is employed. The importance of closely relating the manual work to the regular work of the classroom is so well recognised, that instead of being looked upon as an intrusion, it is increasingly favoured as a means of strengthening and vivifying other studies.

But it is not the purpose of this book to deal with the earlier constructive work, and having mentioned the need of it we desire now to treat of a later form of Manual Training to which these courses serve as a fitting prelude. It may be safely said that none of the schemes of work already referred to offers the same scope and possibilities of steady progression that a well thought out course of woodwork affords. The material itself is pleasant to work on ; it is clean, may be readily shaped, and the tools used in woodworking are more familiar, perhaps, than those used in any other handicraft. It cannot be properly carried on in the classroom, however, but needs a suitably equipped workroom and a specially qualified teacher.

Let us see now why Manual Training should have a place in schools. The aim of Manual Training, as of all teaching, is primarily the quickening of the intelligence. Its peculiar merit lies in the fact that the pupils get their knowledge at first hand ; instead of taking things on trust they see for themselves why success or failure follows their efforts. Education in the past has been almost entirely bookish ; but the current of educational thought is now steadily set in the direction of experimental and practical methods—from abstract generalisations to the handling or making of things themselves. By utilising his motor and constructive activities, the child's innate craving to make something is turned to useful account, and his self-activity develops power in mind and body alike. The cultivated sense of touch, the dextrous use of the hands in prompt and purposeful action, eyes quick to observe and judge correctly—these are not only valuable qualities in themselves, but give mental stimulus also; they are brain-building. Psychologists are emphasising with growing insistence the connexion between the hands and the brain. They tell us that certain areas of the brain are aided in their development by the exercise of certain closely associated groups of muscles, and that when the hands have not received proper early training there is a loss of effectiveness in both hand and brain. It is not too much to say, then, that Manual Training is largely intellectual training; it is another approach to the brain. In handling and measuring his wood or other material, the three dimensions of a solid are realised by the boy with a clearness that arithmetic alone can never convey; and fractions cease to be abstractions. Drawing, also, takes on a new aspect when it represents something to be actually made.

Every opportunity should be taken for closely weaving the Manual Training into the warp and woof of the school-work. Much is missed, unfortunately, because the subjects of instruction are kept apart, each study aiming at its own specific "results" rather than at being developmental. To do this requires time, of course, but much may be done without making undue inroad into the lessons. For example, the properties and the areas of squares, triangles, hexagons, etc.; the cubic contents of various solids; the action of cutting tools; the mechanical principles involved in various tools; the growth and the characteristics of different woods; the fitness of different woods and metals for the uses to which they are put; the application of geometric constructions, and so on. All these afford valuabl training and may be dealt with simply and briefly, a they arise during the progress of the work.

Closer connexion might be made, too, between the art and the manual training rooms. A weakness in much of the art and design work done in school arises from the fact that so little of it is practically applied. Many of the models made in the woodwork class form suitable objects for design, or decoration, and some for both. These designs and decorative effects might very well be prepared during the art lesson after the problems have been discussed by the two teachers concerned. Due regard must be paid, of course, both to simplicity of form and the strength of the material. In ornamenting the plain broad surfaces presented in some of the simpler models, stencilled or mass designs are perhaps most suitable. Many of the brushwork studies may be modified for this purpose. The best work may be varnished or polished, stained, or painted with enamel. Chip-carving, veining, simple gouge-work, gesso, and poker-work are other forms of decoration that may occasionally be tried. Care must be taken that the objects are not overweighted with ornamentation, the decorative elements should be of the simplest. In many cases the natural beauty of the wood is sufficient in itself.

Every effort should be made to cultivate the boys' resourcefulness. The material should not be limited to timber only; wire, Venetian strip iron, tin, lead, sheet-metal should be added to the ordinary Manual Training equipment. The room should also contain at least one wood-turning lathe, and a vice for metal-working. Pupils should be encouraged to make the most of the tools and materials that lie at hand, improvising methods and contriving substitutes for anything they lack. By this means a general handiness will be obtained far beyond that engendered by following out a cut-and-dried scheme of work. The value of this power to adapt means to an end can scarcely be over-estimated. Scholars should be called upon to invent and design models for themselves.

The diversity of the work can hardly be too great. It adds to the interest of the child and gives a wider range of manipulation, with corresponding accession of power to the worker. For educationists there is no feature more striking in the teachings of modern psychology than the fact that strength of will is very largely a question of muscular control, and that this depends for its right development on the early activities aroused by both work and play. The power to do comes of doing. The teacher may guide the pupils' efforts along the path of acquirement, but the actual experience they must obtain for themselves. It is this output of energy in purposeful action that develops and strengthens the will.

" Muscles," says Dr. G. Stanley Hall in *Adolescence*, " are in a most intimate and peculiar sense the organs of the will. They have built all the roads, cities, and machines in the world, written all the books, spoken all the words, and, in fact, done everything that man has accomplished with matter. If they are undeveloped or grow relaxed and flabby, the dreadful chasm between good intentions and their execution is liable to appear and widen. Character might be in a sense defined as a plexus of motor habits. . . . Habits even determine the deeper strata of belief, thought is repressed action, and deeds, not words, are the language of the complete man. The motor areas are closely related and largely identical with the psychic, and muscle culture develops brain centres as nothing else yet demonstrably does.

Muscles are the vehicles of habituation, imitation, obedience, character, and even of manners and customs. For the young, motor education is cardinal, and is now coming to due recognition, and for all, education is incomplete without a motor side. Skill, endurance and perseverance may almost be called muscular virtues, and fatigue, velleity, caprice, ennui, restlessness, lack of control and poise, muscular faults."

There is always a danger of school studies becoming formal. This may arise from over-systematisation, or else from the aim at getting examination results or living up to the traditions of former examinations. The kindergarten itself has suffered at times from a narrowing down of the broad spirit which underlies it to the slavish adherence to a definite set of exercises; so that often the very essence of its teaching has been lost and only the ritual retained. It is not surprising to find, therefore, that the fuller development of Manual Training has been hindered somewhat by stereotyped and restricted schemes of instruction which aimed at results in wood rather than the realisation of the child's powers and potentialities. It has sometimes been forgotten that although tool manipulations have undoubtedly much educational value they yet are incidental rather than vital; not an end in themselves, but a means to an end. There has been too much conforming in the past. Uniformity has become almost an ideal. The uniform course is easy for supervision and that is probably its only merit. But for a teacher to accustom himself to one narrow path and then to tread the same path unquestioningly ever after, is not the highest form of teaching. The work should fit the child, not the child fit the work. This, of course, can only be carried out when there is reasonable liberty. The teacher who is bound down to a set course has little scope for exercising his initiative, with the result that he loses his keen interest and enthusiasm for the work.

Even in Manual Training the old examination demand for results has tended towards a mechanical and lifeless type of instruction, with an over-emphasised demand for accuracy. When the teacher's outlook is limited to results in wood or other material, he has little time or thought to bestow on those finer educational processes which are less readily seen or assessed. To emphasise unduly the aim of rigid mechanical accuracy generally means a sacrifice of the thought side of the work. The qualities which lead eventually to the realisation of the pupils' highest powers—such qualities as intelligent self-direction, the power to plan means to an end, and the cultivation of an alert, resourceful attitude of mind—these are too valuable to lose for such an aim. Exactness will come naturally, in due course, when the boy begins to "find himself," if the instruction be of the right kind. At the same time, it must be understood, no system of handwork counts for much which ignores a reasonable standard of accuracy. But we must not test boys by a man's standard.

To get the most out of educational handwork is by no means easy. The task requires from the teacher both skill of hand and an aptitude for analysing the various processes into simple teaching elements. In addition to these he must have the ability to present them in such a way as will stimulate the intelligence of those under him, and this depends as much, perhaps, upon mental alertness and sympathetic imagination as upon either his knowledge or his training, important as these undoubtedly are.

Enough has been said, it is hoped, to show that Manual Training implies something more than the acquirement of skill, though that in itself is by no means to be despised. It is the quality of mind and the spirit of confidence that it engenders that make handwork so valuable in school. Moreover, it does something to lessen the schoolroom aloofness from the life outside, and helps to give balance to what has hitherto been a one-sided training. It gives point and exactness to other studies, the boys' ideas gaining in strength and clearness from actual contact with things.

In the lower standards as many forms of handwork should be introduced as possible, and care should be taken that the work does not become monotonous. There should be a steady progression both in thought and skill. All the early forms of manual work are valuable just so long as this sense of growing acquirement holds ; so that when a fair amount of skill has been gained, or when the work has ceased to make sufficient demand on the child's mental powers, other handwork should be substituted. While this method of training is undoubtedly good for everyone, none benefits so much, perhaps, as the child who is "slow in the uptake" but handy with his fingers. To him especially it gives confidence and new courage to attack purely mental work.

Town life and the vast changes arising from the introduction of machinery in nearly all industries, have rendered the home singularly devoid of opportunities for exercising the growing activities of children. There is all the more need, therefore, for educating the child in ways that will call into play, and give effective control of, a wide range of muscular movements. Manual Training offers a fruitful field in this direction. It calls into activity mental and physical powers, differing somewhat from those demanded by his other studies, that otherwise would be untouched by his school training.[1] The growth in mental and motor ability thus brought about will contribute some small share to the making of the resourceful, versatile citizen that our increasingly complex civilisation more and more demands.

Although it is only recently that Manual Training has become firmly established as a school subject, the idea is by no means new. The value of manual work as an aid and supplement to intellectual pursuits has been advocated by far-seeing educational reformers in almost every age. Even at a time when school-teaching was so entirely bookish as in Wm. Penn's days, we find him writing: "Children had rather be making of tools and instruments of play, shaping, drawing, framing, building, etc., than getting some rules of propriety of speech by heart; and these would follow with more judgment and less trouble and time." This was in 1693, and we are only now beginning fully to realise the wisdom of utilising the child's outgoing activities by giving them a place in his educational training—to the advantage of muscle and brain alike.

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[1] The biography of genius, even the biography of talent, shows a surprising percentage who have eluded the schoolmaster, and have come out winners. It is no argument against school-keeping, but a very forcible one against ill-advised school-keeping.—C. HANFORD HENDERSON in "Education and the Larger Life."

CHAPTER II

THE CHILD

" Anyone who presumes to write about children must expect to have his credentials challenged."—BISHOP THOROLD, " On Children."

" Truth will not be served until the child's body and the child's mind are studied with the same devotion that we render to every other branch of philosophy and learning."—PROFESSOR J. J. FINDLAY, Introduction to " The School and the Child."

" The child—or, I should prefer to say, a child—is in the first place a young animal ; in the second place an immature intelligence, but in the third, and incomparably the most interesting —he is a person, to wit himself."—R. CARY GILSON, M.A.

" Nature wills that children should be *children* before they are *men*. If we seek to pervert this order we shall produce forward fruits without ripeness or flavour, and though not ripe, soon rotten : we shall have young *savants* and old children. . . . I wish some discreet person would give us a treatise on the art of observing children—an art which would be of immense value to us, but of which fathers and schoolmasters have not as yet learnt the very first rudiments. —ROUSSEAU (1712-1778), quoted by Quick in " Educational Reformers."

" Nature says to a child, ' Run about,' the schoolmaster says, ' Sit still ' ; and as the schoolmaster can punish on the spot, and Nature only long afterwards, he is obeyed, and health and brain suffer."—LORD DERBY (speech in 1864).

" So long as one recognizes that the child is absolutely different from the adult, not only in size, but also in every element which goes to make up the final state of maturity, one is more apt to get a true method of development which must gradually bear the results of a higher evolution."—OPPENHEIM, "The Development of the Child."

IT is by no means easy to realise the state of mind of another person, even when that person is of similar age and general culture. How much more difficult, then, is the task of the adult in trying to realise the point of view from which the child sees things, separated from him as he is by many years of work and thought, of joy and sorrow, and the countless happenings which have well-nigh blotted out the memory of youthful feelings and impressions. Can this gulf of years be bridged over so that we may see things as the child sees them ; understand his likes and dislikes, his difficulties and his potentialities ; why he is discouraged and how he may be stimulated ? To understand the child is as puzzling and baffling a task as any the teacher has to face, and at the same time perhaps, the most fascinating and helpful. "Childhood," as Rousseau said, "has its own way of seeing, feeling, and thinking" ; and for a teacher to confess that he had never seriously tried to understand children and to study their ways, would be almost to declare his unfitness for the responsible work entrusted to him.

The teacher, then, should aim at possessing a knowledge of children far more definite and complete than that possessed by the average grown up person, in order that he may be able to deal fittingly with every member of his class. One of the charges against present day methods of teaching is that the child's individuality is not sufficiently considered. This is largely a question of the size of classes ; no teacher, however skilful, can make his treatment properly suit the varying needs of his pupils when he is burdened with an unwieldy class.

The manual training teacher, however, with his class of not more than twenty boys, has special facilities for suiting his methods to those under him, as so much of the work, if taught as it should be, is individual rather than class instruction.

And yet so complex are children, with their infinite variations, their many-sided lines of conduct, their strangely different personalities under changed conditions, their whims and waywardness, that one's judgments and forecasts are constantly at fault in dealing with them. Physiology and genetic psychology, the one with its records of the changes and development of the body, the other with its investigations of the growth and functions of the immature brain, have done much to give us truer views of child life. Happily, the child is now no longer looked upon as " a little man," but rather as a man in the making. The boy differs from the man as much as the butterfly from the caterpillar, or the tadpole from the frog, and it is only by knowing how this transformation is gradually brought about that education can be made to run with and not counter to his natural growth.

It is fortunate for the trainer of children that there are so many avenues by which he may approach a knowledge of his material, so that when one road fails another may lead to at least partial success. Perhaps the most valuable approach to the study of child-life is to endeavour to call back to mind all that can be remembered of our own early days, when the responsibilities that weighed upon the little shoulders were so different from those that rest there now.

To sit down quietly and try to recall the memories of things that impressed themselves in early years is to become, to some extent, a child again. The more completely the memory retravels the byways of the past the surer we are how children look at the big world around us; investing, as they so often do, the very commonplaces of life with a mysterious and delightful charm that fades with childhood's fleeting years.

These recollections of bygone years will not always come just when we bid them, and at the best our mental pictures of past events lack definition. So much has temporarily gone beyond our power of recall, unheeded in the attractions and interests of the present, that much external aid is needed to fill in the details of childhood's experiences. Friends who formed a part of that early world, events of public interest recorded in the current literature of the time, books re-read, places revisited, or toys seen again, may help the memory to call back the thoughts and emotions, the feelings and conduct of the early springtime of life. Whenever an attempt is made to recall the early memories there is the danger to guard against of reading into the past our later experiences.

To supplement this first-hand knowledge the child can be observed both at work and at play. Without interfering with that spontaneous reaction to his environment, so prominent in childhood, the observer can arrange for changes in the child's surroundings that will do much to elucidate some of the more difficult and subtle problems of child nature.

The child has to be considered both as an individual and as a part of his class. Groups of individuals have definite laws of conduct that alter for the time at least the personality of each individual member. The teacher of a class has before him both a collection of separate individuals, each demanding special treatment, and a mass to be considered as a whole. He has constantly to fluctuate in thought between the idea of his class as a crowd, responding in definite ways to its own laws, and the idea of his class as composed of so many separate individuals, each differing in ways of thought and conduct.

Autobiographic records, such as those of Tolstoi, John Stuart Mill and others, afford many interesting facts concerning the inner nature of childhood, especially the childhood of genius, perhaps the most difficult of all to understand. In addition to these, many reliable biographies of noted men detail incidents in their boyhood that may prove instructive to the student of child nature; at the same time readers of biographies will do well to remember that what they read is retrospective and often has not been gained from actual knowledge or close observation of the person concerned.

The children portrayed in pictures, fiction, and poetry often embody much of real child nature, as all must feel who have read the works of Robert Louis Stevenson, William Canton, or George Eliot. But as a general rule the children of fiction are far from convincing when compared with the living specimens around us. We miss in the children of literature the charming mixture of simplicity and artfulness, the wayward and restless buoyancy, the irresponsibility, and utter disregard of reality that make them so touchingly credulous and whimsical. Your author endeavours to make children think and act in a reasonable grown-up way, but that is not the child's way. They are full of fancies, delightfully unconscious of anything but play; full of happy, heedless desire to live their little lives in their own ingenuously sweet way.

"What are little boys made of?
Frogs and snails, and puppy dogs' tails,
That's what little boys are made of."

Stevenson in his essay on "Child's Play" aptly remarks: "Children are even content to forego what we call the realities and prefer the shadow to the substance." "When my cousin and I took our porridge of a morning," he says, "we had a device to enliven the course of the meal. He ate his with sugar, and explained it to be a country continually buried under snow. I took mine with milk, and explained it to be a country suffering gradual inundation. You can imagine us exchanging bulletins; how here was an island still unsubmerged, here a valley not yet covered with snow; what inventions were made; how his population lived in cabins on perches and travelled on stilts, and how mine was always in boats; how the interest grew furious, as the last corner of safe ground was cut off on all sides and grew smaller every moment; and how in ine, the food was of altogether secondary importance, and might even have been nauseous, so long as we easoned it with dreams."

The observer of child life must not forget to watch the hild at play with other children and when alone. Here it is that the child is most himself. The role he plays in organised games, where leaders have to be chosen and subordinate positions filled, gives good indication of his real character. To this side of child nature properly belong those spontaneous drawings, of men, women, and things, which, when interpreted in the light of fuller knowledge, give helpful hints of the contents of the minds of their producers.

When contrasted with the grown up probably no feature of childhood is more outstanding than that of extreme restlessness. It has been said that children play not merely because it pleases them but because they must. The child is constantly finding something with which to occupy himself; hence his notorious talent for getting into mischief. This ceaseless activity, however, is necessary and essential to proper growth and development, and if directed into right channels will be of considerable help in furthering the child's education.

For this reason if for no other manual training should be *par excellence* the children's subject. But to make it so there must be no unnecessary restrictions placed upon their natural impulse to be always doing something. Children love to make things by themselves, and inwardly resent too great an interference on the part of others. Their pride in accomplishment is marred by too much help ; they will often prefer their own crude results to your more perfect one.

Children are highly imitative, and the younger the child the more he depends upon this attribute for making his "study of the external world," so that actions, both good and bad, more easily spread among the members of a very youthful class. Those teachers whose pupils differ widely in age will have noticed how marked is the "steadying down" towards the end of school life. Dealing with lads of very varied ages is one of the features of the work of the manual training teacher, and to be a real success he must be prepared to modify his methods to suit his pupils.

As we have already seen a vivid, and often uncontrolled imagination, belongs to the period of childhood. This is apt to lead its possessor astray. The mind wanders away on the slightest prompting into realms of fancy. A large part of his time the child dwells in the land of Make-believe. Things without life become animate under the spell of his active imagination. He quickly loses touch with the matter of fact world and just as readily returns to it ; he will at one moment be a most desperate pirate or Indian chief, and the next mildly ask his mother for bread and jam. This innate tendency must be borne in mind when planning out lessons for the early years. For this reason the observation lessons should be so planned that long trains of thought are not called for till the pupils have had some practice in thinking out means to desired ends. To prevent the pupils' thoughts wandering away from the subject, by reason of this natural tendency, concrete things must be freely introduced into the lessons, thus keeping them in touch with reality instead of going where fancy leads. The models must be such as can be quickly made and the steps fairly well known beforehand; later on more latitude can be given and greater demands made upon the pupils' capacity to plan and carry out their work, with ever lessening help from the teacher.

Children possess a notably crude sense of humour which makes it difficult for them to appreciate any but the crudest jokes. Consequently the average age of the class is a factor in determining the kind of humour that may be introduced to enliven a lesson or drive home a telling point. It is through his inability to grasp the humour of a situation that the child so frequently adopts a serious attitude towards things which only raise a smile in his elders. The limited experience of children makes them extremely credulous, taking for granted without question any statement bearing the impress of authority. In this way they learn to regard as possible things which are the very opposite in nature and reality. Their vivid imagination lends itself to the creation of the most surprising anomalies.

A saving grace to this credulity is their curiosity, which causes them continually to enquire into things in which their interest has been awakened. This curiosity, like the restlessness of children, only needs proper guidance to become one of the most powerful factors in the education of a child. Teachers should strive to stimulate the children's natural curiosity in such a way that the thirst for knowledge continues after school life.

This is the true function of the school, and no training has been good that leaves the children with the thought that they have finished their education when they leave school.

Having briefly sketched the more marked characteristics of childhood, it remains now to say something of the different types. Of course no two children are alike in nature any more than they are alike in features. Shyness blends with boldness, courage is hampered with quaint touches of doubt and nervousness; the good and the bad are often strangely intermixed, in fact, the bundle of inconsistences we call a child is a puzzling mixture of impish mischievousness and winsome charm.

> "She is my pride: my plague: my rest: my rack: my bliss:
> my bane:
> She brings me sunshine of the heart: and soft'ning of the
> brain."

Now keeping in mind all these contradictory traits it will easily be seen that it is not possible to mark off types of these temperamental variations—overlapping as they do—in any but the broadest manner. A useful classification for our purpose will be the two contrasting extremes of the *motor* child and the *sensory* child.

The Motor Child.—To deal with the more mobile, the more engaging, and the more self-expressed class first, the motor child is one whose every thought tends instantly to express itself in action, with but little consideration of the why or wherefore. The motor child readily responds to outside influence and this readiness to take suggestions often causes him to be considered sharper than he really is. His quickness of intellect frequently leads to errors being made through want of thought. While this type of child is usually alert and eager to carry out any suggestion that may be given, his power to retain what he learns is generally so weak that he requires several attempts at the same task before the knowledge and the skill abide. He is usually lacking in perseverance and thus presents a certain fickleness of character that needs the hand of authority to keep him to his work. His lively nature makes him very ready to attack a fresh task or carry out a new suggestion, but he dreads the monotony of mere routine work. A pupil of this kind finds it difficult to concentrate for long his rather fluid attention on the accomplishment of some definite end, especially if the steps that lead to it are not novel ones, as the merest suggestion of a new path for his thoughts causes his attention to stray and so leads to almost certain failure. Casual contact with such a pupil will often impress the observer with an idea of intellectual brightness that closer acquaintance is apt to dispel; the brillance is fugitive, lasting all too short a time. He is frequently the victim of his own hastiness, quickly forgets the lesson he should have learnt from any painful result, and has to go through the process again. He readily owns up to his errors, bears no resentment when corrected—and straightway commits a similar mistake. So great is the tendency of the motor child to translate all thoughts into actions that, as Professor Baldwin says, one "cannot lead him into truth, but must drive him back from error." He is dominated by habits, which quickly form in children of this type, and thus has ever to be learning to adapt himself afresh to circumstances. Undue repetition of easily performed actions tends to emphasise the weaknesses of the motor type. His habit of rushing at his work without the slightest reflection should be combated by introducing complications into his task that demand thought before success can be achieved. In the manual training room such a pupil seems best dealt with when his impulsiveness is allowed to work in its own way, leading to the spoiling of the model he has in hand. Then the need for thought, involving as it does a plan of the means by which the end can be attained, should be pointed out to him and he should also be shown that he could easily have won success but for his impulsiveness. In extreme instances it might be well to insist on the steps being written out before the work is commenced as an auxiliary to the information provided by the drawing and to ensure the pupil having intelligently thought out what he is going to do. To pupils of the motor type praise must be sparingly given. Whenever it can be recognised that greater reflection on his part would have brought greater success it must be pointed out to him. His tendency to action is sufficient to carry him through the performance of tasks within his capabilities; what is wanted is that thought shall accompany the successive steps, both in the manner in which they are to succeed each other and in the method by which they can best be accomplished. As the tendency to action is so powerful it is little use commanding such a pupil to keep still: rather let his activities find expression in service useful to himself. Once bring his abundant activity and eagerness under the sway of habitual reflection and his efforts will yield their proper harvest of results. All this will require the greatest tact on the teacher's part; while insisting that the child pays full and proper consideration to his tasks, his natural buoyancy and alertness should not be unduly damped down.

Huxley in an autobiographical chapter says of his mother: "Her most distinguishing characteristic, however, was rapidity of thought. If one ventured to suggest she had not taken much time to arrive at any conclusion, she would say, 'I cannot help it, things flash across me.' That peculiarity has passed on to me in full strength," he adds; "it has sometimes played me sad tricks, and it has always been a danger. But, after all, if my time were to come over again, there is nothing I would less willingly part with than my inheritance of mother wit."

The Sensory Child.—The sensory child is more contemplative, more troubled with physical inertia, and less open to suggestion than his motor brother. To all stimulus he is slower in response, and the outward signs of what he is experiencing are not so apparent because he is less demonstrative. While he is not so apt in learning, his power of retaining what he has learnt is greater than in the motor type of child. He pauses before he allows his thoughts to end in action, and so he makes fewer mistakes. He is more timid in the presence of the unknown and in every case waits for explicit signs of what he ought to do. The fact that his mind does not express itself so vehemently makes him a greater problem than the motor child, whose feelings lie more on the surface. When the feelings of the sensory child have been wounded he grieves in quiet and bears resentment for a considerable time against the agent that has caused his pain. Greater care is needed therefore in dealing with such a child, as the wrong treatment may put a barrier between him and the teacher that time alone can remove. Every endeavour should be made to win and retain the confidence of such children, for their sensitiveness makes them easily wounded and they will brood over their, often imaginary, wrongs. The sensory child should be encouraged to express himself more readily both in speech and manner. He should be induced to talk, and it should be made plain to him that by being too reticent he loses much of the help that would otherwise be offered him when in difficulty. Above all he should be made to feel that his treatment is always just. When he has made a bad performance of some piece of work, he should be induced to repeat it willingly. This can best be done by showing him where he has failed and by pointing out to him the pleasures of success. On account of the lack of ideas that the sensory child has, when compared with the motor child, his work should be more varied and fuller of suggestion. In this connection he should be led to design parts of his work for himself whenever he can do so. In judging the finished work of such children the successful parts must be pointed out as evidence that even greater success is possible in the future, while the mistakes should be dealt with in a kind and sympathetic manner, at the same time showing how they may be avoided next time. The child's confidence in himself seems to be wanting, and oftentimes the suggestion that a little "dash and go" is wanted will enable the sensory child to achieve more satisfactory results. The direction, "Go at it as if you had done it a thousand times before!" will help a child lacking in self-confidence; this and a little judicious overlooking of minor blunders will work wonders. Show that you have confidence in his ability so that he may feel confidence in himself, and take every opportunity to bring him out of himself. With the sensory child "nothing succeeds like success." The true teacher finds as much satisfaction in bringing out the sensory child as in toning down the hasty actions of the other, and his skill is shown by the degree to which he can foster and develop what is best in each.

While keeping in mind the two broad general divisions of motor and sensory children, we must also remember that each of these types includes children who depend for acquisition of knowledge more particularly on one of the special senses rather than upon them all. Some employ in this way the sense of sight and are termed *visuals*, while others make a greater use of hearing, these being known as *auditives*. Thus a visual will comprehend directions better by reading them than by merely listening; while an auditive will learn by what he hears more quickly than by what he sees. Naturally each class of child must be appealed to when we deal simultaneously with groups; but in individual instruction more attention can be paid to these important differences in our pupils.

Children present different selves to different persons just as we ourselves do. It is often difficult for the teacher to avoid setting up a feeling of antagonism between the child and himself; nothing is worse than a policy of feeble conciliation on his part, and he must trust to a consistent display of fairness and justice to dispel any temporary feeling of repellency. It is equally the teacher's duty to restrain the wild impetuosity of the wilfully headstrong child, and to spur on the lamely irresolute youth who habitually waits for direction under each and every new set of circumstances. And through it all—guidance, control, and suggestion—the less obtrusive the teacher the better. Children should not be denied the experience that comes of choosing and deciding for themselves: in Carlyle's phrase, "to be poured into like a bucket is not exhilarating to any soul."

Obvious as it now seems to us to view education from a full consideration of child nature, the general recognition of this is only of recent growth. It required the genius of such educational pioneers as Rousseau Pestalozzi, Froebel, and Herbart to bring this about, and to lay the foundation of the modern standpoint that the school must suit the child, and not the child fit the school. Nothing is more striking in the history of education than the strange neglect to take into account the real nature of children in devising schemes for their training. Happily there seems no danger that this will be lost sight of again.

Manual Training, with its free opportunities for the outlet of natural activity, especially ministers to the needs and nature of the child; and along with the greater bodily freedom necessary to perform the tasks should go increasing mental freedom, as the child progresses, if he is to get the greatest good from a course of educational handwork. It must never be forgotten, then, that the child is the most important item in the manual training room. The stuff we have to act upon is the child, the wood or other medium is only a means to an end. The more we understand of child nature the fitter we are for our task. "Study what you most affect."

Sympathy is the best quality of a teacher, especially the sympathy that can feel *with* the child as well as for him. That, and a lively sense of our own childish days, will help more than anything else to lay open to us the mysteries of the young mind. Observation alone will not do it. Take a flower or a plant and you may by observation, comparison, experiment, etc., get reliable results of an object very complex in structure. But in studying humanity we deal with material vastly more complex. Pursue the same method with children and how far would you get? How much would you know of their feelings, motives for action, likes, dislikes, and all the subtleties which make children what they are?

No! it will not do. Children cannot be known from the outside. Everything will need to be interpreted in terms of the observer's own experience and feelings. Children, as we have tried to show, are not all of one pattern; and the observer may have had a narrow or perhaps uncommon training; but be that as it may, it seems to be the only standard by which to test one's judgment of others. Out of ourselves we must rediscover the ways and feelings of childhood, by reviving our early impressions and testing and criticising them in the light of our later years. A teacher ought to have —were it possible—a second childhood, just to see what it is like; not so much because we do not know, but because we have forgotten.

CHAPTER III

MOTOR TRAINING—THE ACQUIREMENT OF DEXTERITY

"I think it difficult to exaggerate the importance of varied training in skill. It is indeed, in my opinion, of primary importance in the early stages of education and for some time onwards. Nor should it at any time during the preparatory years of life be neglected."—PROF. LLOYD MORGAN, "Psychology for Teachers."

"The possibility of all education is based upon the existence of the power which the nervous system possesses of organising conscious actions into more or less unconscious, or reflex, operations."—PROF. HUXLEY, "Elementary Physiology."

"Education consists in the modifications of the central nervous system. For this experience the cell elements are peculiarly fitted. They are plastic in the sense that their connections are not rigidly fixed and that they remember, or, to use a physiological expression, tend to repeat previous reactions. By virtue of these powers the cells can adjust themselves to new surroundings, and further learn to respond with great precision and celerity to such impulses as are familiar because important."—PROF. DONALDSON, "The Growth of the Brain."

"The fundamental point in the psychology of an occupation is that it maintains a balance between the intellectual and the practical phases of experience. As an occupation it is active or motor; it finds expression through the physical organs—the eyes, hands, etc. But it also involves continual observation of materials, and continual planning and reflection, in order that the practical or executive side may be successfully carried on. Occupations as thus conceived must, therefore, be carefully distinguished from work which educates primarily for a trade. It differs because its end is in itself; in the growth that comes from the continual interplay of ideas and their embodiment in action, not in external utility."—JOHN DEWEY, "The School and the Child."

SIT back in your arm-chair—smoking the while if you like—and reflect carefully upon what you have done and what has happened to you during the day. By so doing you will better comprehend the variety of human conduct. You can, perhaps, remember that a certain none too obedient lad did some particular thing contrary to your orders, and in response to his action you adopted a definite line of conduct. So clearly are such infrequent incidents stamped upon consciousness that you may actually feel, at least slightly, a recurrence of the emotion that originally accompanied the event you are calling to mind.

Can you, however, definitely say which foot you raised first when mounting the doorstep on coming home to tea? Probably not. What then is the difference in these two experiences that makes the memory of the one comparatively clear and definite, while the other is so far unnoticed and forgotten that the greatest uncertainty exists when trying to recall it? A slight and necessarily brief sketch of the way in which the mind works will help to make the matter intelligible; but it must be remembered that the limits of the space at our command for such a sketch prohibit all but a mere outline being placed before the reader, and this should be regarded at the most as a preliminary to further study of some of the works on the subject enumerated in Chapter VI.

The study of psychology shows that the great majority of human actions are responses to stimuli of one kind or another. The stimuli are received by the various organs of the senses,—the eye in the case of sight, the ear in hearing, and so on,—the resulting actions being the work of the muscles.

In order that the stimulation of the sense organ may give rise to appropriate movement, there must exist some communication between the sense organs and the muscles responsible for the movement. This communication is carried on by two kinds of nerves—those transmitting the stimulus, called sensory nerves, and those carrying the impulse to the muscles, called motor nerves. These sensory and motor nerves are not continuous with each other, but go to a common centre through which the various sensory nerves may have direct communication with various motor nerves, forming what are known as sensori-motor arcs.

The centres themselves are grouped into three "levels," each having functions somewhat distinct from the rest. The lowest or third level has its seat in the spinal cord and medulla, while the highest level is seated in the highest parts of the brain.

The work of the lowest level includes the regulation of such automatic actions as the beating of the heart, breathing, and other important and constant functions of the body. In addition to this, it also carries out another large group of actions of somewhat similar character, inasmuch as they are purely involuntary and little under the control of the individual's will. What is known as the "eye reflex" is an example of such involuntary movements. Let anything threaten the safety of the eye by approaching it suddenly then the eyelids close instantly. So spontaneous is the closing of the eyelids under these circumstances that it requires considerable effort and some practice to prevent the eyelids from shutting even when no real danger is to be apprehended from keeping them open. A lad knocking in nails may thus often be seen to close his eyes sharply at every blow of the hammer. At this lowest level actions are performed with great accuracy and but little hesitation. Such are said to be "natural reflexes," further examples being sneezing, coughing, etc.

Functions of the highest intellectual character are the work of the first or highest level having its seat in the topmost portion of the brain, known as the cerebrum, of which the cortex or grey matter is the most important part. Here it is that deliberation takes place when two or more possible lines of conduct are open to the individual; here it is that the highest forms of thought arise, and the ultimate direction of conduct is determined. Professor Royce in his "Outlines of Psychology" says: "The brain cortex directs, by itself alone, and apart from the co-operation of the lower nervous centres, no externally observable motor process. What it does is partly to combine and elaborate, partly to guide by slight alterations, and partly to hold back or to *inhibit* the activities which other centres, left to themselves, would carry out in response to the sensory stimuli which reach them. The brain also arouses the lower centres to act in its service by substituting its own external disturbances." It is in the cortex that the centres of many of the simpler functions have been localised and areas marked out as belonging to speech, hearing, etc.

Between the first and third is a second level having its seat in those parts of the nervous system that lie between the upper brain and the medulla and spinal cord. The main function of this level is to take over the performance of certain actions which have become reflex in character owing to frequent repetition. Walking over the front doorstep, originally controlled by the first level, is now the work of this middle level, having become what is called an "acquired reflex," in contradistinction to such "natural reflexes" as sneezing, etc. Under proper conditions the sight of the step is sufficient to cause the raising of the foot, whichever foot it may be.

An illustration may make this clearer. Suppose we compare the working of the brain with the administration of a national system of education. The highest level will then be represented by the Board of Education and its officers, while the lowest level will be represented by the teachers and scholars—merely as an illustration of course. The way in which the Board of Education controls the whole educational system is analogous to the way in which the highest level controls those below it. To take an instance: suppose the Board of Education come to the conclusion that each boy shall do a certain amount of drawing in every Manual Training lesson, whether the practical work demands it or not. They issue orders to the second level in the educational system—the Local Education Authorities—who in turn issue their orders to the teachers and through them to the scholars. Now, whenever the Board of Education issues an order which induces the teachers and scholars better to co-ordinate their present functions, and which at the same time leads to the smoother carrying out of school duties, then the order is naturally complied with. Should, however, this not be the case, then the local authorities, through their inspectors, have to enforce the order and thus practically take part in carrying it out; while in turn the Board of Education have to see that the local authorities do their part. Let, however, the order be executed without any hitch by the lowest level and there remains no need for the control of the higher levels. This particular work soon drops out of their consciousness, allowing new demands to be formulated by them and imposed upon the important lower levels.

It is a conspicuous characteristic of repeated action, both mental and physical, that as it becomes more skilfully carried out the less is consciousness involved in its execution. An expert batsman has no time to "think" how he shall deal with every ball he plays, but must trust to his acquired batting reflexes; the cricket ball under certain conditions gives rise immediately to certain definite strokes. In other words, habits have been formed of dealing in certain ways with certain things. It is the work of education to promote the formation of these correct habits.

A practical example of the way in which the work of the various centres is combined in the process of creating new habits will be found in the case of a lad learning to saw. Simple as this operation seems when considered as a step in the production of an easy exercise or model, it is by no means so simple when we come to analyse it.

The pupil, having attentively watched the teacher during a demonstration in sawing, takes the tenon saw into his own hand for a similar purpose. At first he pushes the saw across the wood, expecting it to cut as well as it did in the hands of the teacher. To his surprise the expected does not happen, for the saw catches and sticks. Determined to succeed, the lad draws the saw back and adds vigour to his effort so that now the saw cuts well into the wood, but the effort is not yet entirely successful and he has to try again. This time, either by chance or from the teacher's directions, the effort is modified so that the unnecessary bearing downwards, so general with the pupils at first, is eliminated, and almost complete success results. During these repeated attempts there is a lessening of those useless movements of the mouth, etc., which nearly always accompany the first attempts at doing what is new.

What suggests to the lad when the saw catches and sticks that perhaps a harder push will be successful? It may be that sometime in his experience something similar has occurred—perhaps an extra effort knocked a boundary when a gentle drive failed to score a run; or perhaps an obstacle which was pushed against only gave way when it was "shoved"—and this past experience is acted upon as a model for present action. Or again a number of "shots" may be made at doing a particular thing, each "shot" differing from the previous ones by reason of what has gone before, and from the fact that random movements are introduced spontaneously into the efforts. Face twitchings are examples of random movements, useful for instance in learning to talk. Should any random movement prove an aid to success it is immediately "selected" and forms part and parcel of the fresh endeavours; on the other hand, all useless movements tend to be eliminated. Thus we see the pupil's efforts grow more successful and definite by "practice." In all this the teacher acts the part of an ultra-experience, shortening the "making perfect by practice" method by introducing into the lad's early efforts elements leading to useful and definite results which otherwise might be long in getting there. The lad does not consciously go through all we have stated any more than we ourselves do in gaining expertness in some particular direction. In fact it is not easy to trace back, even after considerable reflection, exactly how we acquired dexterity in such things as shaving, riding a bicycle, or bowling a cricket ball. But whenever we have reflected upon what we are doing and suggested to ourselves new lines of effort, while trying to acquire some new dexterity, success has been obtained more quickly and with less expenditure of energy.

To return to the sawing operation. The lad has learned to saw, so far as cutting the wood is concerned, but to his surprise has failed in one important point. He has not sawn "square." To what he has already learnt has to be co-ordinated the act of keeping the saw square. At first, the conscious effort to do this spoils the freedom of his strokes, and not till the sawing again becomes automatic in character is it done easily and well.

While he is conscious of his efforts the highest centres of the brain are controlling his actions, but as the need for conscious direction grows less so does the accuracy of the process increase ; till finally the act is regulated almost entirely by the lower centres.

The economy of this division of labour among the centres of the brain is obvious. Take such things as the acquirement of ability to read and write. These accomplishments are obtained slowly and with much mental effort. In the earlier stages when a word is written every stroke of the pen and each curve of the letters must be carefully considered during the process. Later on, words are dashed off without hesitation and without conscious effort. The upper brain, which had the control of the process of acquiring the act, has now passed the work over to the lower centres as routine work. Thus, when action of a volitional character has been made mechanical through habit, the higher level of the brain is set free to initiate and follow new directions. As Dr. Maudsley points out, " If an act became no easier after being done several times, if the careful direction of consciousness were necessary to its accomplishment on each occasion, it is evident that the whole activity of a lifetime might be confined to one or two deeds—that no progress could take place in development. A man might be occupied all day in dressing and undressing himself; the attitude of the body would absorb all his attention and energy; the washing of his hands or the fastening of a button would be as difficult to him on each occasion as to a child on its first trial; he would furthermore be completely exhausted by his exertions."

From another point of view sawing square is a *habit* brought about because all actions, mental or otherwise, once performed tend to be repeated in a similar way each time the stimuli necessary to start them occur. If a boy holds the saw in a certain way when sawing the first time, there is a tendency to hold the saw in a similar manner the next time he takes it in hand. This is the reason why so much importance is placed upon the correct handling of tools in the early attempts. But though habits are thus formed and persist from the first there is not always that permanence that some would have us believe necessarily attaches itself to all habits.

Professor James in his "Talks to Teachers" lays stress on the fact that habits are most speedily fixed when no exception is allowed to occur till the habit is securely rooted. This of course would imply full command over all one's actions; but teachers have not the power to place the child in such favourable circumstances however much they may desire it. Cross influences are at work forming habits in the child that may not merely hinder but actually prevent the formation of desirable habits. It must not be forgotten that even before a child first comes to school many habits are already firmly established, and that it is often a part of his school training to unlearn these. Thus the habits of the school have often to fight their way against the habits of the home and of the street, and these sometimes persist in spite of all the teacher's efforts. In fact, while the work of the school consists in the formation of habits, it must be borne in mind that it has not only to form habits that are desirable but has to cultivate them in spite of the exceptions that inevitably occur. Old habits have to be interfered with or broken down, just as a child's natural activity has to be controlled during the first years of school life. The child has to bring into play his power of inhibiting, or preventing, movements that otherwise would get free play. To restrain his spontaneous activities is often the most difficult task that can be set a child. It is not always realised how hard it sometimes is for a child to sit still; the mental effort required to block the outlets for nervous energy is often much greater than is required to initiate action.

As we have seen, in all bodily movements the result of experience and practice is to hand over to the lower centres the control of actions that at first involved the direct control of the highest centres. It follows, then, that in making the more advanced models the pupils should saw, chisel, etc., in fact, do all the frequently repeated manipulations in the work, with ever-decreasing consciousness of the process. On first teaching a new manipulation a highly skilled teacher will have to go slowly, step by step, through that which he is going to teach in order that he can analyse the elements that make up the whole and so realise what is needed for the successful carrying out of the operation. He will not be conscious of the different co-ordinations of the various muscles involved unless he has already done the analytical work required to determine them.

"What!" some one may ask, "Is the aim of educational woodwork to teach lads to work without thinking?" To some extent, Yes. Professor John Adams has stated: "From a certain point of view, all education may be said to consist in the elimination of consciousness from certain processes, or, in other words, the transforming of conscious processes into unconscious processes. It is not to be supposed, however, that this implies that the goal of education is to produce a perfect automaton. The human organism must never be reduced *as a whole* to an automaton, but the greater the number of processes that can be rendered perfectly automatic the better." But however perfectly the manipulations involved in a new piece of work are carried out, however great the skill in craftsmanship, there always remains work for the intelligence involving the exercise of the higher brain centres. Their function is to control and organise the dexterity possessed, and to correlate the various forces at the command of the individual, so that they may render him the greatest possible service—the successful gaining of the end in view.

Everything depends upon consciousness concentrating itself at the right point if success is to be both speedy and complete. But when actions involving skill are thoroughly mastered, the less consciousness enters into the work the quicker and more certain will be the reaction. Many familiar acts, such as running rapidly up or down stairs, cannot be performed successfully if the self-consciousness that accompanies them is very great.

> " The centipede was happy quite,
> Until the toad, for fun,
> Said, ' Pray which leg goes after which ? '
> Which worked her soul to such a pitch
> She lay distracted in the ditch
> Considering how to run."

In the acquirement of dexterity the process is largely a sub-conscious one—a coming in of practical experience and the acquisition of appropriate responses. Training makes new pathways, or causes the old movements to become more mobile. In Dr. Carpenter's phrase—our nervous system grows to the modes in which it has been exercised. The child is constantly modifying his ways of doing things, getting greater command over his muscular activities and improving his power to react to new conditions. It is a method of trial and error; skill may not come at the first attempt, nor does it always persist; failure follows success, or success comes but slowly, yet through all the fluctuations there gradually grows an increasing power of adjusting the mechanism of the body to the end in view. Practice gives greater accuracy and lessens fatigue. Actions which at first and for some time require constant effort and attention are finally so wrought into the system that the necessary movements are touched off by a very slight impulse from the brain centres. We may thus look upon the brain as a storehouse of those past experiences and impulses which determine very largely the response made by the individual to new conditions—controlling, influencing, and modifying all future thought as well as future action.

CHAPTER IV

INTEREST AND ATTENTION

"Everyone who wishes to interest others *must himself be interested.*"—PROFESSOR ADAMS, "Primer on Teaching."

"We need not fear that by an appeal to the everyday interests of the child we may make education too easy or deprive it of that bracing effect on the will which results from the effort to overcome the difficulties of studies of a more abstract and less interesting kind. Every teacher should understand that good teaching does not merely enlist a languid interest in the child, or allow him to be a passive recipient of information given; on the contrary, the purpose of teaching is to stimulate an active interest and attention. The special value of Manual Training and observation lessons lies in the fact that they help so largely to achieve that purpose; but every lesson should be designed to require the scholars to do something they have not done before, to overcome some difficulty not yet encountered."—"Suggestions for Teachers," *Board of Education.*

"In the case of mind, no study pursued under compulsion remains rooted in the memory."—PLATO.

"I think we shall find on consideration, that no one succeeds in any occupation unless that occupation is interesting, either in itself or from some object that is to be obtained by means of it. Only when such an interest is aroused is energy possible. No one will deny that, as a rule, the most successful men are those for whom their employment has the greatest attractions. We should be sorry to give ourselves up to the treatment of a doctor who thought the study of disease mere drudgery, or a dentist who felt a strong repugnance to operating on teeth."—QUICK, "Essays on Educational Reformers."

TEACHERS almost universally agree that attention and interest are of supreme importance in education. If it be possible anywhere to make use of these two great educational levers it surely is in Manual Training.

A stranger entering a well-ordered manual training room during one of those happy periods when everything is going along just as it should be, at once notices the noise made by the lads at work. He hears the combined sounds of hammering, sawing, planing and mortising as the boys work out their respective tasks. The experience, if a new one, is so foreign to his conception of school life, that he naturally and instinctively looks for considerable disorder among the pupils. To his surprise he finds on closer investigation of what is before him that the tasks are being carried out with an earnestness and eagerness that show the thoughts of the young workers to be thoroughly concentrated upon what they have in hand. Our visitor, when he has noticed this, is almost sure to give expression to his surprise by saying, " The boys are interested in their work." He has observed the lads paying *attention* to their work and from this he has inferred the *interest*. Without attention the lads could accomplish nothing, for it is only when consciousness is concentrated upon some object or idea that anything rises clear and definite before the mind.

While in the waking state the mind habitually pays attention to the ideas or objects before it, though in the case of a so-called inattentive pupil it may not be the idea most desired by the teacher that occupies the central position in the mind. His thoughts have wandered away from his task, but he may still remain in a state of attention, other ideas filling his mind and striving to express themselves in action. The sight of a few shavings on the bench may suggest to such a lad the idea of putting them down his neighbour's neck ; and it then needs the intrusion of some new object upon his all-too-receptive mind to prevent him from carrying the idea into practice. Such new object of attention may be the sound of the teacher's voice bidding him get on with his work. Neither the visitor on the one hand, nor the boys working at their separate tasks on the other, may experience any effort in keeping attention fixed upon what is before them. In one case, the novel sight of a room full of lads at work with tools, and in the case of the boys the making of their models, may so easily and naturally fix the attention that each mind remains concentrated upon the object before it. Attention of this involuntary, spontaneous or passive nature is quite opposed in character to that involving a direct effort of the will such as is generally necessary in carrying out some uncongenial task. The difference between involuntary and voluntary attention is seen when a boy has a task for which he has no desire and for which he sees no reason beyond the teacher's orders, and the same lad with a task of which he feels the need, and knows that the carrying out of which may benefit him. Such a difference often exists between a so-called "disciplinary exercise," merely set in order that the lad may learn to work at tasks which do not of themselves appeal to his natural interests, and the same exercise or joint set as a preliminary to some important piece of work involving its use.

In the first instance the lad finds the constant effort to keep his attention fixed a strain upon his natural powers, and consequently the work becomes tiring and suffers in execution; while in the latter case even the real difficulties are attacked without hesitation and the whole becomes a pleasure. In an uncongenial disciplinary exercise the attention is thus sustained by sheer will power, giving us voluntary or volitional attention, while in an attractive model the attention is more securely maintained by the natural pleasures of the work, the attention being spontaneous in character.

The more this involuntary attention can be drawn upon in carrying out tasks the smoother will go the work of the school; while the more the will is involved the greater the mental strain upon the taught, and the more frequent the lapses of attention.

At the best voluntary attention comes only in beats. No mind can possibly continue to attend for any length of time to an object which does not demand attention for its own sake and which does not change. This may be proved by trying to keep the attention fixed upon the white margin of this book. When the margin is only considered as a white surface the attention quickly flags and other ideas rise before the mind. But if the margin in turn is considered in relation to its position, meaning, extent and availability for notes, etc., the mind can almost indefinitely prolong the period of attention. In putting ideas or objects before children, whose attention easily wanders, it is desirable that the ideas and objects be approached from many sides in order that they may find no difficulty in keeping their attention fixed upon what is presented to them.

Up to the present we have merely been considering attention from the point of view of mental activity; it now remains to consider the springs from which attention naturally rises. Our visitor hit the mark when he said, "The boys are interested in their work," for the mainspring of attention is interest.

Professor Stout says, "Stumpf, indeed, goes too far when he says 'attention is identical with interest,' but the distinction between them is simply that the word *interest* carries with it a reference to something else as well as to attention as a mode of mental activity; this something else is the pleasure-pain tone of the attention process."

The mouse being played with by a cat pays attention to the cat as much as the cat pays attention to the mouse, and their attention is akin, but though each has an interest in the actions of the other yet the cat's interest has a pleasurable tone while the mouse finds it decidedly painful.

Interest itself may be either *direct* or *indirect*. In the one case the thing is interesting because it is desired for its own sake, in the other it is interesting because it leads to attainment of the object sought. A boy desiring to make a certain model will find each step interesting because it leads to the fulfilment of the anticipated pleasure of ownership, though as purely disciplinary exercises some of the self-same steps might prove tedious to him. In the first case the successive steps have a kind of borrowed interest that really belongs to the completed work ; this is what is termed indirect interest. The pleasure experienced by the beginner when making his first attempts at sawing, planing, etc., gives a direct interest to these simple operations. For this reason it is not so necessary to commence a course of woodwork with models from the first ; the early exercises, if not too many, are sufficiently interesting to draw the best efforts from the pupils. Still even here a model having a definite purpose will in some cases be a greater incentive to good work, though not necessarily so in all.

In teaching, indirect and often artificial interests are made to play an important part as stimuli to greater care and attention on the part of the scholars. When judiciously used the principle is a wise one, but such devices must be carefully scrutinised in order that harm may not come from their application. Teachers of educational woodwork naturally feel that the models themselves, together with the natural satisfaction the boys have in making things, should be sufficient incentive to appeal to every pupil without exception. To add a monetary reward for each successfully completed model might certainly add a greater interest to the completed work, but would be a case of setting up an artificial interest in the place of a natural and healthy one.

On the other hand, to alter the usual size or shape of a model in order that it may thereby be made more useful to a particular pupil, is a legitimate method of adding to the interest incited by a model. To make a thing interesting does not necessarily mean making a thing easy, in fact the intrinsic interest may be considerably lessened or even altogether lost by so doing. Nowhere is this more evident than in games of skill in which the honour belongs to him who accomplishes what the others cannot attain to. In the manual training room the same spirit is often evident. Some boys, well advanced and skilful in their work, were asked if they would rather have a model lasting say three months or one lasting not more than three weeks. They agreed unanimously that they could not take an interest in easily and quickly made things, but liked difficult pieces of work, because they were "worth doing." This explains why the practice of giving every new manipulation as a preliminary exercise does not always increase the efficiency of the models. When a new manipulation is involved in a model it incites carefulness and thought, because the interest is so great and the sense of difficulty or newness braces up the mind to its best efforts. A preliminary exercise has not the interest of a model and spoils the subsequent repetition of a manipulation by taking the newness from it. There are cases in which it may be desirable to preface a very difficult model by practice in this way, but the method is not so successful in getting better work as is commonly imagined. It is, however, impossible to make all school-work interesting, and it is certainly desirable that the pupils learn to do things just because they form part of their school duties. This is a necessary preparation for after-life, where duty demands many tasks not pleasant in themselves must be done. A lad at school must learn to accomplish tasks cheerfully and well, whether they appeal to him or not. This is part of the discipline of school. Sir Oliver Lodge in "School Teaching and School Reform," says: "Study should be attractive of that I am convinced; not superficially but solidly attractive; nothing is more stimulating and essentially pleasurable than to feel that you are really making progress and acquiring a mastery of something." He further lays a charge against the incompetent and uninteresting teacher when he says: "If he (a child) is asked it will be found that the class he likes best is that which has the best teacher, and the study he hates worst is that presided over by an incompetent teacher. He does not know the reason and charitably considers it the fault of the subject; but the subject itself has no fault, the fault lies in its presentation." If this is the case it is certainly all the more imperative that we as teachers do what lies in our power to make our subject as deeply interesting as possible. This can be better done by the use of interesting methods than by trying to titillate the fancies of the pupils by use of fictitious claims upon their attention. The aim in teaching should be to excite a healthy, living interest in the subjects under consideration. Such interest grows as it strives to seek self-satisfaction, and the result is not merely the acquisition of a larger fund of information but the founding of new habits and the building up of a worthy character.

At first it would seem that what is entirely new must prove most interesting; but a little consideration soon makes it plain that this is not so. When the lads are interested in things, such as tools for example, we invariably find that it is because they already know something about them, the familiar attracts while what is altogether strange repels. If as an illustration we take the case of the saw, we find a newcomer already knows something of the possibilities that lie in the use of that tool. He has seen the butcher cut through a bone, or his father sawing firewood, and to these ideas he adds the pleasurable remembrance of his own self-activity. This leads him to expect that the saw in his hands will be a source of intense pleasure and consequently he is eagerly attentive while the teacher gives him his first lesson in its use. This assimilation of the new ideas with the old is what the Herbartians term *apperception*, which means, as Prof. Adams in his delightful work on "Herbartian Psychology" puts it, "the acting upon a new idea by all the ideas at present in the soul, and since the number and arrangement of ideas in no two souls are exactly alike, it follows that no two persons can have precisely the same idea of anything." It is of course this difference between the ideas belonging to the members of a class that makes the teacher's work so difficult, and he must therefore take pains to ensure that he knows, as far as he can under the circumstances, how his class stands in this respect. Having made himself acquainted with the ideas already existing in the minds of his pupils the new must be presented in a manner which emphasises the natural connexions between the new idea and the old ones. This aspect of presentation of new ideas is further treated in the chapter on "Observation Lessons." A subject may be made interesting if the pupils can be led to feel that it personally concerns them. The boy who is going to be an engineer may feel an interest in the metric system of measurement when he knows that it may be adopted in industry generally. A lad has been known to work hard at a series of joints because someone he knows has used them in building a rabbit hutch. School-work must be made interesting from every possible point of view if it is to appeal to each member of a class; hints for doing this are often unconsciously given by the lads if encouraged to discuss their work with the teacher.

While interest in one's work increases the attention given to it, it does not follow that attention necessarily leads to interest. Therefore to demand a pupil's attention with the idea of engaging his interest will not be successful unless the natural interests of the subject are sufficient to retain his attention when once engaged. For this reason demanding attention with a loud voice in an imperious manner is usually condemned by educationists, and it can only avail when the compelled attention is fixed on suitable material. The attitude of attention is familiar to all teachers, the most impressive feature of it being the concentration of the pupils' whole activity upon the matter in hand; they have lost the desire to do other things, or to be attracted by other objects. What posture should be taken up by the attentive pupil depends upon the circumstances under which his attention is demanded, but generally speaking the position of least physical strain is one conducive to the greatest attention. A class may be sitting most demurely, and yet the attention may be wanting, while a class in which each member has found the position easiest for himself may be attentive to every detail of what is going on before them. This must be decided by the teacher when he knows his pupils. But it should not be forgotten that the class must take an active part in what goes on if they are to remain attentive long. A lad whose interest is seen to be flagging may be brought out in front of the class to do something, or a question addressed to a boy by name will rouse him to a new sense of what is going on.

In all the teacher must inspire by his own interest, he must be enthusiastic in his work and in his subject if he wishes to inspire interest in others. "Great interest," as Thring said, "will make up for want of time. Create great interest."

CHAPTER V

DISCIPLINE

" Discipline is that part of education which, on the one hand, immediately assures the industry of the pupils by maintaining good order in a school and exciting their zeal, and which, on the other hand, working for a more remote and higher purpose, prevents or represses irregularities of conduct and tends to train resolute wills, and energetic characters, capable of self-control.

" It has the double purpose of establishing the actual government of the school and teaching pupils to govern themselves, when they shall have left school and escaped the tutelage of their masters."—COMPAYRÉ.

" When the environment is so arranged that childish activity can itself find the track of the useful and spend itself thereon, then the government is most successful."—HERBART.

" In the matter of the moral training of children, a most important factor will be the habitual conduct of the teacher in the school. The example of his patience, kindness and determination to be obeyed, of his constant watchfulness and scrupulous fairness, will evoke similar traits in his pupils, and will give point and force to formal instruction."—" Suggestions for Teachers," *Board of Education.*

" Genuine success in the government of boys can only be attained through those higher qualities that are essential to the government of men."—H. W. EVE, M.A.

" A child's character is his attitude to his environment, an attitude which may be masterful or servile, true or false, kindly or hateful. The first axiom for the teacher to assimilate is that there are natural elements at work in the child making for a good character. Give him a chance and he will show initiative, prefer the truth and exhibit affection for those about him. He must be encouraged along these lines, and great care must be taken to throw no obstruction in his way."—ERNEST CROSBY, "Tolstoy as a Schoolmaster."

THE question of discipline arises whenever a number of pupils are gathered together for the purpose of being taught. Consequently in every age philosophers and schoolmasters have attempted solutions of the various problems that gather under this head.

In each case the scheme of discipline advocated is the reflection of the writer's views as to the true nature of man—what he is and what he should be. When all mistakes, bad judgments and errors of conduct were considered to be the recurrence of "original sin" in children they were to be met with harshness and dealt with in no uncertain manner. To have reasoned with an erring child, under the influence of "original sin," would have been to hold argument with the devil, and as none but arguments of a summary nature could be ventured with that embodiment of evil none was allowed.

Those who would recommend a similar harshness and sternness to-day are in an ever-decreasing minority. This is due to sounder knowledge that exists concerning the true nature and meaning of childhood.

The discipline of the martinet is no longer thought suitable for children. Kindlier methods of discipline have been found more successful in subduing undesirable traits; the better nature of the child instead of being suppressed is stimulated to fuller growth and self-expression.

The manual training room has its own problems of discipline due to the special conditions of work and the short time during which the scholars are under the teacher's control. Along with the bodily freedom necessary in doing the practical exercises—moving about the room to fetch or return some special tool, sharpen the plane or chisel, use the glue, etc.,—corresponding mental freedom should also be allowed.

True discipline does not involve complete immobility on the part of the class: "the true test of discipline is not perfection of order but readiness of obedience."

The teacher's purpose in maintaining discipline is that each separate unit under his control shall be fully occupied and fully interested in his work. If the teacher can do this naturally with ease, there will be little cause for him to trouble about methods of discipline.

A pupil occupied and interested in the working out of his tasks, with due regard to economy of material and of time, has already learnt that which will help him in every day life—self-discipline. And after all, self-discipline is by far the most valuable guide for conduct.

The discipline of the handicraft room, as of any other part of the school, must be *natural* and based upon the laws governing child nature. To alter the nature of a child is beyond the power of a teacher; all that he can do is to try to develop it along the lines he desires. To demand too prolonged attention from children is to run counter to child nature; and to demand the impossible is to court certain defeat.

Consistency in discipline is essential, the same action being treated in a similar way each time it is repeated. If a certain action merits blame and receives it on one occasion the same result should follow if it occur again. Naturally, while the treatment ought to be of the same character each repetition ought to be modified to suit the new circumstances.

The *justness* of the teacher's methods should be apparent to all the members of the class, though each individual should be made to feel that he stands entirely upon his own merits when receiving praise or blame.

In passing judgment upon attempted tasks the motive and the ability of the pupil must receive consideration. When blame is necessary there is special need for thoughtful consideration on the part of the teacher.

It has been put on record by an Inspector that "he is a very ignorant teacher who resents instead of welcomes the honest failures of his pupils." In dealing with such honest failures the teacher's justness must be evident, so it may be well to consider how such failures arise and from what causes.

In every lesson we have three elements that contribute to the success or otherwise of that lesson: (1) the materials; (2) the teaching; (3) the pupil.

(1) The material is placed first because the efforts of both teacher and pupil may be greatly hindered by unsuitable material. When a lad is learning to draw, if the pencil is not a good one the chances of success are then decreased. Should a boy be chiselling badly the first thing to look to is the state of his chisel and after that the condition of the wood, and further, perhaps, it may be necessary to look at the bench vice, or other apparatus used.

(2) After the materials comes the teaching. Have the instructions been given in the proper way, and can the lad from his own particular standpoint comprehend them with sufficient definiteness to make use of them?

That nineteen out of twenty boys have successfully worked from the given directions is no proof that the failure of the twentieth is other than an honest one. Perhaps the very fact that he *is* the only failure may be the sign that he has failed honestly; he may differ from the rest; his intelligence may be wanting or his strength smaller, and in many ways his ability and knowledge may differ from that of the others. Supposing all the boys to hear but this one, what is to be said to him who has failed because he is slightly deaf? The teaching in his case must be modified to suit his condition. There are, as every experienced teacher knows, children hardly deaf enough to recognise the fact themselves. They have always been used to getting their directions with the same disadvantage of deafness, and not knowing what it is to hear completely think all is well. So with the other senses. Therefore the teaching must be considered both as to matter and method before the failure can properly be said to rest with the pupil.

(3) Last comes the re-examination of the pupil. Unless a pupil can comprehend his faults he does not merit blame on account of them. The child's standard of accuracy is not that of the teacher, and his work, therefore, should be judged according to his experience and ability. A piece of work that depends for results upon the eye and sense of touch can only be made as correct as the acuteness, or otherwise, of these senses in the pupil will allow. Of course it is part of the pupil's training to have his shortcomings of perception pointed out, if only that he may be given the opportunity to cultivate them aright.

A lad " all thumbs " cannot do the work of his more gifted companion, and must be gradually and sympathetically trained to deftness in the use of his fingers by suitable exercise. Roger Ascham in his " Scholemaster" wrote: "But this will I say that even the wisest of your great beaters do as oft punish nature, as they do correcte faultes, yea, many times the better nature is sorer punished." This we must avoid.

Unobtrusive discipline produces the most permanent result, and the more the pupils feel that it is their own efforts toward right conduct that avail the better it is for them. The teacher should never suggest by his bearing the least possibility of his power being called into question; his authority is his natural right and should be taken for granted.

The more a teacher can naturally compel obedience to his rules the greater is his influence. Here it may be well to warn the young teacher against the immoderate use of commands, of the inutility of loud talking, when continually used, and the futility of always finding fault without sometimes praising what is good.

That discipline should be firm goes without saying. Once a command has been issued it is the teacher's duty to himself as well as to his pupils to enforce that command. A good rule is never to give an order unless there is every chance of it being carried out.

The results of discipline such as has been described should be the formation of good habits both in conduct and in work.

When the pupils are engaged in bench-work the state of order in the manual training room should be different from that prevailing while the pupils are engaged in drawing, or listening to the teacher. When two lads working on opposite sides of the same bench are engaged upon similar tasks mutual help will result from consultation, "two heads being better than one." This may be allowed so long as it does not disturb the class. By this means the pupils make themselves to a greater extent independent of the teacher and they learn to be mutually helpful, a gain to both as everyone knows who has tried to explain some difficult point to one in doubt.

Whatever tasks the pupils are engaged upon, they should learn to respond promptly to a given signal calling for the attention of the whole class, though here deep interestedness in his task may cause the pupil to be less punctual in answering the signal than he would be otherwise. For this reason the signal should be a sharp and definite one, plainly heard in all parts of the room.

Habits of truthfulness and honesty are inculcated by the pupils' treatment of materials as well as by their conduct in other respects. Therefore they should be taught to regard each step in the process as being important; the fact that some finishing process follows should not be allowed to blind the pupils to the need of careful and thoughtful work in the preliminary stages. Hidden parts of work must not be slurred over because they will not be seen. The difference between doing this and putting the best material to the front can be pointed out to him. The work we do comes from ourselves and we are responsible for it; but we cannot always select our own material and it is right to make the best of what we have so long as actual deception is not practised.

True discipline is based upon motives and instincts that are natural to the child, the principal of these being:—

1. *The love of Praise and fear of Censure.*—Upon both these instincts the wise teacher will strive to work sparingly, for to be always praising is as bad as to be continually finding fault. Each stage of the work shown by the pupil should receive the careful judgment of the teacher and its faults, if any, be pointed out, the teacher reserving his criticism for the finished product. In this way will be built up a sense of the value of self-judgment in all the pupil does.

Praise should be given when the task has been carried through with promptitude and effort, and not merely because the result is a good one, which may be due to the natural ability of the pupil apart from any special application or industry. There is much to be gained by letting the pupils feel that the teacher has a high opinion of their powers. A suggestion that the class is doing well, and may do better still with a little greater effort, sometimes has surprising results.

Two other methods of dealing with the pupils have been so admirably stated by Sidgwick in his helpful essay on "Stimulus," that we may be excused for making a somewhat lengthy quotation and so drawing attention to the complete essay.

"There are two false methods on which I would like to say a word: they are what I call the satirical and the nagging. I will take nagging first. By nagging I mean a constant fire of little rebukes to one and another for inattentiveness. It wears out the patience of the best regulated boy to receive or even to hear such rebukes. It is exasperating to human nature and is utterly futile. Moreover, it distracts and worries the teacher and destroys what chance there was of any real stimulus to attention. My own advice would be this—you may have in many lessons to caution once or twice; but, if you find the thing becoming common look elsewhere for the cause and cure. The probability is you are becoming dull. Either quicken up a bit or at any rate vary the proceedings. But don't nag. It may of course be not your fault. The weather may be hot; or there may be some excitement toward: a great match after school, or races in the vicinity, or some new promotions to the eleven, or news has come that the ice bears upon the reservoir. Anyhow don't nag. If it is hot, open the door and any remaining window; if it is an excitement, try and compete with it, rather than choke it by nagging. I have learnt the futility of this method by having tried it,—and failed.

"The other false method is satire. Whatever a man can or cannot learn, he can at least learn to avoid that. It is nearly always a fatal mistake. Perhaps occasionally, if used among the older and higher boys, and only very rarely, and under real provocation, and used in a kindly spirit, and by a man known to the boys to be really kind, and finally to the right boy, it may be successful once in a way as a stimulus. I need scarcely say these conditions are rarely all observed. It tends to become a habit and to be used indiscriminately: it reacts on the master's temper: and it is very hard to know the right boy."

2. *Sympathy with the Teacher.*—A just and sympathetic teacher easily commands a willing obedience from his class that is impossible to a teacher not having their good will and friendliness. As Thring of Uppingham put it, "The teacher must be full of human sympathy, inwardly exhaustless in kindness and patience, willing to bear anything but refusal to be taught and fertile in resources even for that."

Tasks that do not otherwise appeal to the pupils will often be willingly endured for a teacher in whom the pupils have confidence, so that "a good teacher will lead on his workers to accept the toil which alone makes strong." Instead of such a one commanding the backward scholars to "stay in," to make up some of the ground they have lost, he will merely suggest that perhaps they would like to have this opportunity, and the result is a gain because of the willingness with which they then apply themselves to the task.

3. *Emulation.*—Rousseau wrote: "Emulation is a disposition dangerous to the truth, but education can transform it into a sublime virtue." The history of education shows an almost complete approval of the use of emulation as a means of discipline. When honest friendly rivalry has not been allowed to degenerate into dishonest ambition or jealousy it can be a useful method of spurring on the pupils to make their best efforts, though some systems have in the past made too exclusive use of it.

4. *Rewards and Punishments.*—In Manual Training the

work to a large degree proves its own reward and no other should be necessary in the majority of cases to spur the pupil to do his best. The method of awarding the work may reasonably add to the stimulus afforded by the possession of the successfully accomplished task. If it is usual to keep the work to the end of the term or the end of the year, special reward to a more than usually persevering student can be made by giving a piece of work away immediately it is finished, while on the other hand bad conduct will be suitably met by the longer retention of the work or by withholding it altogether. The coloured and more expensive woods may be reserved for those who have finished the last task well; or sustained efforts lasting over a certain period may be rewarded by the pupil being allowed to suggest and design a model for himself.

When a model has any utility, such as a picture frame, the requirements of the lad may be considered so as to add interest to the work. In the case mentioned, the frame can be made to fit some picture or certificate that the pupil values. So great is the stimulus of having one's own work that the unfortunate ones can legitimately be encouraged by giving them a piece of work well within even their limited powers, so that they can take something away as the result of their labours and enjoy it in secret. Perhaps even kissing it in the privacy of their bedroom as one who is now a teacher once confessed he did.

Awards in the way of *marks* are valued largely as the teacher values them, and unless they lead to some end have little value in the pupils' eyes. If they lead to a position on a list exhibited to all the class or to the enjoyment of certain privileges, they may help to sustain a pupil's interest in his work, but the work itself and the joy of having done it well should be the mainsprings of correct conduct in this respect.

5. *Corporal Punishment.*—Notwithstanding all that may be done in the way of managing pupils by the methods already enumerated, there often comes a time in the development of the average healthy, self-willed schoolboy, when no amount of "moral suasion" avails. In fact, some of the rules of discipline mentioned are effective, now and then, solely because it is known that the appeal to reason is backed by the sterner power of force if needed. The manual training teacher should be granted the right to use corporal punishment therefore. The knowledge that the power is there, will in most cases prove sufficient. Its possession is often nine-tenths of the law. Only when other methods have been tried and failed and after the culprit has been fairly warned, should force be resorted to. With highly nervous or delicate children every effort should be made to avoid the use of the cane. Special care should be exercised in dealing with very sensitive children.

Upon this thorny question, often treated with a sickly sentimentality, we should like to quote the opinion of men like Matthew Arnold, Pestalozzi, and other famous educators, but a quotation from a modern student of child-life—one who is sympathetic in the extreme and yet fully cognisant of the true facts—must suffice. "Does this mean corporal punishment is to be used? Yes, just as physic is to be used. If our child is ill it is because we were too busy or too ignorant to prevent it—then we must give physic after a careful diagnosis of the case. If we meet the case in time a hot water bag will answer. It is the same in the moral world; if our children are bad we are to blame,—if we see it in time a loving but strong hand placed upon the arm is enough. If we have to physic or whip it is because someone has blundered." Professor Earl Barnes, "Studies in Education," vol. i.

In spite of the natural interests attached to the work, in spite of the child's love of activity, and in spite of all that an enthusiastic and sympathetic teacher can do to prevent serious breaches of discipline, such will sometimes occur. The other methods of dealing with the delinquent, such as the loss of marks, the loss of work, detention after school hours, or any attempt at reasoning, may fail to have any effect upon a specially offending member. Such a one must be punished as he merits, not only for his own sake but as an example to the class.

On this point Thring, in his "Education and School," writes: "The faults which principally call for the rod are discipline faults and wilful faults. For instance, when a boy persists in coming late for school; when a boy is impertinent; when a boy, by wilful idleness, accumulates book-punishments until the work comes to a dead-lock, these and similar cases require the rod; the more so as they are entirely in a boy's own power, and no one need incur the penalty unless he chooses. . . . That there is sensitiveness about being caned or flogged is certain, but it is bodily not mental pain that causes it, unless it is administered on wrong principles and in a capricious way. Abstract the pain, boys would not trouble about the imaginary disgrace." However, the use of the cane requires careful thought on the part of the teacher and should be used as "the last resort" in all systems of discipline. It tends to be less used as a teacher gains experience in teaching, but nevertheless there is a definite place for it as one of the penalties of wrong-doing. All discipline depends for success upon the tact of the teacher, ofttimes "a little judicious blindness and deafness is a great virtue in a teacher."

In discipline as in most other things, prevention is better than cure. True discipline looks ahead, it anticipates and prevents even more than it represses and punishes disorder. The teacher's method is all important. Even Pestalozzi failed as a practical teacher on account of his "unrivalled incapacity to govern," as he himself termed it. And Pestalozzi, in spite of his rich endowment of hope and patience, and his power of winning the love of his pupils, had to resort to the rod.

One of the pleasantest features of present day school life, after all, is the kindlier feeling that has sprung up between the teacher and the taught. Most teachers *know* from their own personal experience how much the discipline of the whip has diminished since they were schoolboys themselves. The spirit of the age is against all forms of repression as curative agents. All true teachers now seek to strengthen the children's powers of self-direction, so that they may leave school finally with the elements that go to the making of self-governing and self-respecting members of the community.

CHAPTER VI

THE TEACHER AND HIS READING

"To the teacher, as to all others, experience is the best, if also the sternest of all instructors; and no one can supersede the necessity for her often painful lessons. But the *pain* of *some*, at least, of her lessons she does not grudge to remit to those who are humble enough to learn from others, and not to despise the application of truths because they are known to be so very true."—F. W. FARRAR, D.D., "General Aims of the Teacher."

"Experience is never limited and it is never complete; it is an immense sensibility, a kind of huge spider web of the finest silken threads suspended in the chamber of consciousness and catching every air-borne particle in its tissue. It is the very atmosphere of the mind."—HENRY JAMES, "The Art of Fiction."

"Teaching is the noblest of all professions but the sorriest of trades."—FITCH, "Lectures on Teaching."

"They (books) are masters who instruct us without rod or ferrule, without angry words, without clothes or money. If you come to them they are not asleep; if you ask and inquire of them they do not withdraw themselves; they do not chide if you make mistakes; they do not laugh at you if you are ignorant."—"The Philobiblon" of Richard de Bury.

"A man's most important education begins at the maturity of his faculties, the time at which it is commonly supposed to end."—R. W. MACKAY.

"Read not to contradict, nor to believe, but to weigh and consider. Some books are to be tasted, others to be swallowed, and some few to be chewed and digested. Reading maketh a full man, conference a ready man, and writing an exact man. And, therefore, if a man write little, he had need have a good memory ; if he confer little, have a present wit ; and if he read little, have much cunning to seem to know that he doth not."—FRANCIS BACON.

"The work of true education *is pure research* ; really good teachers are engaged in nothing else, being constantly occupied in studying the pupils' idiosyncrasies, in devising suitable methods of instruction."—PROFESSOR ARMSTRONG, "The Teaching of Scientific Method."

THOSE who have read Dean Stanley's inspiring life of Dr. Arnold will remember the letter that this famous headmaster of Rugby sent to a friend concerning the choice of a teacher. "What I want," wrote Dr. Arnold, "is a man who is a Christian and a gentleman, an active man and one that has common sense and understands boys. . . . I prefer activity of mind and an interest in his work to high scholarship ; for the one may be acquired far more easily than the other." And in a letter to a master on his appointment he states that the teacher should have "sufficient vigour of mind and thirst for knowledge to persist in adding to his own stores without neglecting the full improvement of those whom he is teaching."

Read in their fullest and widest sense these requirements concisely summarise the chief qualities that give success to a teacher and make him an influence for good with his pupils. To specify in elaborate detail all that goes to the making of a good teacher would be somewhat futile ; for teachers as well as scholars, as we have tried to bear in mind throughout this book, differ in so many directions that what is unfavourable to success in one, may prove no hindrance to another. Of the attributes that a teacher should possess none are more valuable and generally useful perhaps than these : (1) Enthusiasm and love for his work of teaching ; (2) Fondness and sympathy for children ; (3) Character and ability along with freshness of mind, imaginative insight, and alertness to his surroundings; (4) Power to govern and manage his pupils tactfully. These are the qualities that *make* a teacher. A man may have a thorough knowledge of and deep interest in his subject and yet fail in the difficult art of teaching, if he is not endowed with a fair share of the gifts which have been mentioned. While these are the main essentials, it is desirable also that the teacher should be of a cheerful and sanguine disposition, firm yet kindly, just, methodical, and blessed with a sense of humour. Readers may amplify the list of virtues to their own content—for ourselves these suffice. As to the manual training teacher, he should have both the teacher's tact and power of imparting knowledge and the ready manipulative skill of the trained craftsman.

A word or two may be here said on the power to govern pupils. To learn how to secure discipline, and how to keep his class interested, are among the first things the teacher needs. Till these are obtained there can be no real attention. Fortunately, the attractive character of the handwork lessons does much to keep the children keenly interested. On the other hand, the greater freedom of movement necessary to such work lends itself to undue disorder if not watched. Coming into the work without previous teaching experience, as so many manual training teachers do, the instructor early realises there are many points to be considered lying quite outside the range of his qualifying certificates. How to handle his class, to maintain order, and to deal with the puzzling variations in his pupils—these are matters he afterwards finds out for himself, slowly, and not without dearly bought experience. The trouble with the inexperienced teacher, very frequently, is that he tends to devote all his attention to individual pupils rather than to the whole class. It is only when he has acquired the power of keeping his eye ranging over the room so that he can quickly detect anything wrong even while giving individual attention, that order is maintained with the minimum effort.

The personality of the teacher is such an important factor in school-work that it is sometimes contended that teachers are born and not made. On the answer given to this depends one's opinion whether a man becomes a better teacher by reading books on teaching. It is true that many very able teachers pay scant respect to the science of pedagogy. They believe in "learning by doing," and assert that the diploma of teaching capacity is conferred by the British schoolboy and not by the college lecturer on school management. Undoubtedly the best training in the art of teaching is that which comes from actual work in the classroom; and for a man of brains and ability, endowed with the temperament that commands discipline without effort, there is little need, perhaps, that the "resolution" to be a teacher should be "sicklied o'er with the pale cast of thought." But all are not thus happily gifted with the qualities of the born teacher, and most of us may learn a great deal from books, if they are of the right sort.

The thing is not to look upon books as a substitute for experience, but rather as supplemental to it. Experience is undoubtedly the best guide, yet personal experience may be too dearly won if it is gained only after much profitless experiment on the pupils. "An unhappie master he is, that is made cunning by manie shippe wrakes," as wise old Roger Ascham said. A study of contemporary and historical methods of teaching will do much to prevent these "many shipwrecks," so long as it is not pursued with the sole idea of finding ready-made systems to save one the trouble of planning out his own lessons and schemes of work. Success in teaching, as in much else, comes as a rule only after much stubborn fighting, and each must straighten himself for the task. "If you want knowledge," writes Ruskin, "you must toil for it; and if pleasure, you must toil for it. Toil is the law."

When Professor Huxley was asked if he could impart the secret of his wonderful facility and power as an essayist, he answered, "Nothing could be simpler; I read all that is worth reading on the subject, make myself practically acquainted with the essentials by observation, think it over for twenty years or so, and then just commit the net result to paper."

It is the "thinking it over for twenty years or so" that makes experience so valuable; for mere experience counts but little, unless insight and observation have accompanied it. A thoughtful teacher will always be striving to improve his methods and will obtain hints and suggestions for improvement from very many sources besides that of books.

The convenience with which books may be consulted, however, makes them particularly acceptable to the busy teacher. "Consider what you have in the smallest chosen library," says Emerson. In that pregnant word "chosen" lies the secret of forming a helpful library. For it is not the number of books a man possesses that makes him a thoughtful man; nor the value of his library that makes him intellectually wealthy. Many books may be read before the most valuable ones are come by, if one goes without a guide, though as experience ripens each may safely choose for himself. "It seems," writes Emerson, "as if some charitable soul, after losing a great deal of time among the false books, and alighting upon a few true ones which made him happy and wise, would do a right act in naming those which have been bridges or ships to carry him safely over dark morasses and barren oceans, into the heart of sacred cities, into palaces and temples. . . . Private readers, reading purely for the love of the book, would serve us by leaving in each the shortest note of what he found." With the idea then of helping those who have not read many educational works we venture to offer the following list for guidance. It is not claimed to be in any way an ideal selection, but we trust it is one that will stimulate the beginner to further reading and prove a source of renewed inspiration to all.

The books more directly valuable to manual training teachers may be roughly divided into four classes: (1) Educational works dealing with the history and methods of education, including works on special branches such as Manual Training; (2) Works on Child-Study; (3) Psychological works; (4) Works on Physiology and Hygiene.

(1) Among educational works of the historical kind the beginner cannot do better than commence with Quick's "Educational Reformers" (Longmans, 3s. 6d.), a teacher's library in itself, or Oscar Browning's "Educational Theories" (Kegan Paul & Co., 3s. 6d.). "A History of Education," by Thos. Davidson (Constable, 5s. net), treats of education as an evolutionary process from the earliest period to the present time. Other books on the history of education are Compayré's "Lectures on Teaching," translated by W. H. Payne (Heath & Co., 7s. 6d.), and "Educational Opinion from the Renaissance," by S. Laurie (Cambridge University Press, 6s.).

Among the general treatises on education there are Spencer's "Education," now published as low as sixpence, by Watts & Co., and Locke's "Thoughts on Education," of which many editions exist, the best being that edited by Quick (Cambridge University Press, 3s. 6d.).

Dealing more particularly with method we have Adams's "Primer of Teaching" (Clark & Co., 6d.), an admirable little book, written primarily for Sunday school teachers but helpful for all. M'Murray's "Elements of General Method" (Macmillan & Co., 5s.); "Suggestions for Teachers," issued by the Board of Education (Wyman & Sons, 8d.); Sidgwick's charming and highly suggestive essay on "Stimulus" (Cambridge University Press, 1s.); Fitch's "Lectures on Teaching" (Cambridge University Press, 5s.); "The New Movement in Education," by Thiselton Mark (Charles & Dibble, 6d. net); Armstrong's "The Teaching of Scientific Method" (Macmillan & Co., 6s.); Miall's "Thirty Years of Teaching" (Macmillian & Co., 4s. 6d.); "Principles of Class Teaching," by J. J. Findlay (Macmillan & Co., 5s.); "The Logical Bases of Education," by J. Welton (Macmillan & Co., 3s. 6d.).

Most of the books dealing with "School Method" are more helpful to the teacher in the schoolroom than to the handicraft teacher, though it is as well to read at least one to gain a knowledge of the methods advocated for the modern school.

The student of educational literature will find a large and increasing number of books on Pestalozzi, Froebel, and Herbart—that noble trio of educational reformers. Translations of the original work of these great teachers are not easy reading, so that the beginner will do well to commence a study of them by reading some of the following books. Hayward's "Critics of Herbartianism" (4s. 6d.); Felkin's "Introduction to Herbart's Education" (6s.); Herbart's "Science of Education," with introduction by Felkin (6s.)—all these are published by Swan Sonnenschein & Co.; "The Educational Ideas of Froebel," by Jessie White, and "The Educational Ideas of Pestalozzi," by J. A. Green (University Tutorial Press, 1s. each).

Well written biographies of schoolmasters, such as Stanley's "Life of Arnold," Fitch's "Thomas and Matthew Arnold," "A Memory of Edward Thring," by J. H. Skrine, stimulate and inspire, and leave upon the mind an abiding impression.

Among works dealing with Manual Training are: "Theory of Educational Sloyd," by Otto Salomon (Phillips & Son, 3s. 6d.), deals with the educational value of handwork; "Manual Instruction: Woodwork," by S. Barter (Whittaker & Co., 6s.), contains an excellent and varied collection of models, with very clear, detailed working instructions; "'The New Education,' Manual Training: Woodwork," by R. Wake (Chapman & Hall, 10s,), advocates the designing of models by the children themselves; contains a series of excellent object lessons, and is altogether a suggestive book; "Hand and Eye Training: its Principles and Methods," by H. Holman (Clarkson & Griffiths, 1s. net), a clear statement of the aims and claims of handwork in school; "Learn by Doing," by J. H. Judd (Clarkson & Griffiths, 5s. net), an admirable attempt to solve the problem of providing a simple scheme of woodwork for young children at low initial cost; "Elementary Sloyd and Whittling," by G. Larsson (Boston: Silver, Burdet & So., 75 cents), has some good toy models; and a course of knifework that may be done in the ordinary classrooms; "Bench Work in Wood," by W. F. M. Goss (Ginn & Co.), chiefly for notes on tools; "Manual Training: Metalwork," by J. S. Miller (Whittaker & Co., 3s. 6d.); "Woodwork for Schools on Scientific Lines," by Baily & Pollitt (John Murray, 2s.), contains a number of models for the laboratory and physics courses.

When reading works on educational woodwork it is well to bear in mind the late Herr Salomon's words. "Pedagogical systems—just as much as religious and philosophical systems—risk the danger of stiffening into lifeless and life-killing forms of letter worship. I fear that this has already happened to the Nääs system, and that those who say the 'pointer' has become a dogma are entirely right." The pointer is not the only model that has become a dogma, other systems have their wooden dogmas also.

Revolutionary views of modern education are to be found in Well's "Mankind in the Making" (Chapman & Hall, 6d.); "School Teaching and School Reform," by Sir Oliver Lodge (Norgate & Williams, 3s.).

(2) The books on Child-Study are constantly growing in number, it being only during the past few years that Child-Study has been recognised as a subject worthy of study by those who have to deal with children. For a commencement no better book can be found than Drummond's little work, "The Child" (Dent & Co., 1s.). Other works on the same subject are Barnes' "Studies in Education"; Baldwin's "Mental Development"; Preyer's "The Mind of the Child"; Sully's "Studies of Childhood"; Oppenheim's "Development of the Child"; Marenholtz-Bülow's "The Child and Child Nature"; Groos' "Play of Man"; and Chamberlain's "The Child." All these are well worth reading. Drummond's book as well as Chamberlain's contains a list of further works on Child-Study.

(3) Among books on Psychology the world renowned works of William James stand pre-eminent for lucidity of thought and aptness of illustration. "The Principles of Psychology," in 2 vols. (Macmillan, 25s.), is his chief work. The teacher should not miss Adams's "Herbartian Psychology" (Heath & Co., 3s. 6d.), a delight-

fully interesting work on the subject of its title. Simple books on this large and somewhat technical subject are Ryland's "Story of Thought and Feeling," and Baldwin's "Story of the Mind," both published by Newnes & Co. at 1s. Margerison's "Ethics and Education," and "Psychology and Education," are good introductory little books for students (Ralph, Holland & Co., 1s. 6d. each). Larger and more ambitious works on psychology are those of James, Sully, Royce, Stout, Hoffding, Dewey, Ladd, Scripture, and others. Physiological-psychology is dealt with by McDougall in a small primer bearing the name of its subject as a title, and published by Dent & Co. at 1s.

(4) Works on Physiology and Hygiene abound in considerable numbers. A useful handbook is Thornton's "Advanced Physiology" (Longmans, 4s. 6d.), while larger works, such as those of Foster or Waller, can be consulted at the libraries. Rowe's "Physical Nature of the Child" (Macmillan & Co., 5s.), treats of the child from the physical standpoint, giving the methods of testing the senses for detecting any divergence from the normal. Huxley's "Elementary Physiology" still retains its high place among physiological works, while "The Physiology of the Senses," by M'Kendrick and Snodgrass, is an up-to-date work on the special department of physiology with which it deals.

Other works of general interest are to be found among the following series: "Library of Useful Stories" (Newnes & Co., 1s.); "Great Educators" (Heinemann, 5s.); "Pedagogical Library" (Heath); "The International Education Series" (Appleton); "Contemporary Science Series" (Walter Scott & Co.,); and "International Science Series" (Kegan Paul & Co., 5s.).

Books dealing with Tools, Drawing, Trees and Timber, etc., are mentioned in the chapters relating to those subjects.

Besides the special books we have mentioned, there is a vast field of educational and general literature—Biography, Essays, Fiction, etc.—all more or less helpful. The choice of such works is best left to the individual, who can select from the numerous cheap reprints a most valuable list and can supplement his own shelves by the use of public libraries. Current periodical literature often contains articles helpful to the teacher, while *Manual Training*, the official monthly journal of the National Association of Manual Training Teachers, gives much useful matter dealing with the work of the handicraft room.

It is very helpful when a number of teachers engaged in doing similar work gather together periodically for the discussion of ways and means in teaching. For some time past a number of such groups have been working in London with very satisfactory results.

As a final word we quote from Fitch's "Lectures on Teaching" the following advice to teachers: "When your strictly professional work is done follow resolutely your own bent; cultivate that side of your intellectual life on which you feel that the most fruitful results are to be obtained, and do not suppose that your profession demands of you a cold and impartial interest in all truth alike, or that what to others is a solace and delight, to you is to be nothing but so much stock in trade." Let your work bear the impress of the man in you besides that of the teacher.

CHAPTER VII.

OBSERVATION LESSONS AND HOW TO IMPART THEM

THE ART OF QUESTIONING—NOTES OF LESSONS—THE HERBARTIAN STEPS

"Observation is the absolute basis of all knowledge. The first object, then, in education, must be to lead the child to observe with accuracy; the second, to express with correctness the result of his observation."—PESTALOZZI.

"Education in which the training of observation plays a considerable part will not be open to the objection of being exclusively bookish, and by insisting on the use of the scholar's own senses as a pathway to knowledge will lay the foundation for a right direction of his activity and intelligence during his school life and afterwards."—"Suggestions for Teachers," *Board of Education.*

"Children should be led to make their own investigations, and to draw their own inferences. They should be *told* as little as possible, and induced to *discover* as much as possible. . . .

"Object lessons should not only be carried on after quite a different fashion from that commonly pursued, but should be extended to a range of things far wider, and continued to a period far later, than now."—HERBERT SPENCER.

MOST of the lessons given in connexion with Educational Woodwork may be fittingly termed observation lessons. The chief aim in giving these lessons should be to train the scholars to observe with exactness and to think and reason upon what they see; to compare and contrast and to form sound judgments based upon their own direct observation of things.

It is a somewhat trite saying that "the eye sees only what it brings with it the power of seeing." This is often used in the sense that we should train our eyes to see simply for the sake of seeing. Suppose you are asked, How many lamp-posts did you pass in going to school? and were told that you are lacking in observation because you are unable to answer. Would you straightway begin noticing these useful erections, or counting the number of doors you pass, and so on? This would be improving your habit of observation. But to what end? The cultivation of observation means more than this, it really means the storing of the mind with a well-arranged body of knowledge and interests; it is this that constitutes the "seeing eye," not the mere training of the senses to record a string of isolated and uninteresting facts. If we desire to encourage observation in any direction we must prepare the necessary mental background with which the new matter will "compose." We can all notice things when they are pointed out to us which we should never perhaps have found out otherwise; but the full appreciation of what is observed depends on what is already in the mind. It is this assimilation of new facts with knowledge and interests already in the mind that properly constitutes observation. The difference between "eyes" and "no eyes" is almost entirely a difference between intelligent interest and lack of interest in what is observed.

Hence whatever else the teacher strives for, he must strive to be interesting. Children are full of curiosity, that is to say they are full of interests, but of interests often in things other than those under consideration. It is not, then, so much a question of *creating* interest as of *directing* it into the right channel. How shall I give this lesson? is therefore a point requiring the teacher's careful thought.

Having settled upon a suitable plan as to the order of the lesson, it is always desirable to begin with some fact the children are quite familiar with, in order to get on common ground. Have in view some definite aim as the desired outcome of the lesson, and make every point assist in driving this home; bearing in mind that "a new idea is like a wedge,—it must not be driven in by the blunt end." The class should be made to take an active part in finding out things, nothing being told that may reasonably be drawn out by questioning. In his desire to get along with the lesson a teacher sometimes leaves too little for the children to do themselves, forgetting that it is no part of his task to save the pupils from exerting themselves. In the same way the strong desire to complete a subject and have done with it often defeats the end in view by giving too much matter for proper digestion. There is a limit to sustained interest and this should not be overtaxed. Cultivate the art of omitting non-essentials, especially in the earlier lessons. Teach slowly is a wise maxim: a lesson is only given when it is *taken*—by those for whom it is intended.

The teacher must ever keep in mind not only the subject of his lesson as it appears to him, but also how it is likely to look from the child's standpoint. Steele's remarks on "Conversation" may easily be applied to this branch of the teaching art. "I would establish," he said, "but one general rule in conversation, which is this, that men should not talk to please themselves, but those that hear them. This would make them consider whether what they speak be worth hearing; whether there be either wit or sense in what they are about to say; and whether it be adapted to the time when, the place where, and the person to whom it is spoken."

A study of child nature and the laws of mind development will be of great help in fitting our methods of instruction to the child's capacity. The greater the psychological attainment of the teacher, the less chance there is of going wrong in this respect. But no amount of abstract knowledge will give a sympathetic insight into the scholar's feelings unless it is backed up by close observation and due experience. The valuable gift that goes under the name of "tact" in teaching is often acquired unconsciously, quite apart from text-book instruction, by exercising judgment upon the results of practical experience in class. Tact will always be needed in dealing with individual peculiarities.

It does not necessarily follow that all should teach in the same way, any more than all should write the same hand. What really matters is that both should efficiently serve their end. Here, as elsewhere, the personal equation will count. It will be helpful to note the effect of the lesson, and, when the class has been more than usually attentive and interested, to try to find out the reason. In like manner if pupils are listless it is always wise to see if the fault lies in ourselves. Have we been listless in giving the lesson? Has the method of imparting it been stereotyped and dull? It is not likely that the class will be interested if we show no interest in the lesson ourselves. As Arnold once said, "The desirable feeling to entertain is always to expect to succeed, and never to think you have succeeded."

A bright delivery counts for much. We have all at one time or another been surprised to find next day how well a speech or lecture has read in the newspaper report, that bored us considerably the night before. And yet a close scrutiny may convince us that the report is a reliable one—the weariness resulting from the manner in which it was delivered. Another source of flagging attention, and what is worse of misunderstanding and confusion, is a want of clear articulation on the teacher's part, a fault responsible for many curious misconceptions. A teacher need not, however, covet the orator's gifts and easy facility of speech; brilliancy is not so much needed as earnestness and a settled plan.

Although cleverness in speaking is not indispensable, it will invariably be found that a good teacher is a clever questioner. The art of questioning plays such an important part in cultivating the intelligence of children, by testing and directing their thoughts, and by bringing them into active participation in the lesson, that we shall now consider it in more detail.

THE ART OF QUESTIONING

Knowledge may be imparted orally either by lecturing—you address the pupils and they simply listen to what you say—or by a process of questioning—you draw from the pupils by skilful questions all they know bearing upon the subject, and then lead them to discover as much as possible themselves, telling only such facts as must be told. By itself the first of these methods is quite unsuitable where children are concerned. Children are not sufficiently developed in mind to absorb information in bulk, no matter how well arranged it may be, simply because they have not the adult's power of concentrating their thoughts upon a subject for any length of time. Their attention will wander constantly if they are asked to remain merely passive listeners. By making use of the method of question and answer the children are made to take an active part in the lesson. The advantages of this course will now be dealt with.

For convenience, the many different forms of questioning will be classed as of three kinds—Preliminary, Instructive, and Examinatory.

The *Preliminary*, or experimental, question is used in much the same way as an army uses its scouts, to find out how the land lies. The teacher puts out a feeler in this direction and in that till he has found out how much the pupils already know of the subject he is dealing with; otherwise, the lesson would be apt to lack connexion with the present acquirements of the class.

Instructive questioning may next be brought into use. Here the aim is teaching pure and simple. The subject is planned out in the teacher's mind, and he endeavours by a series of questions, which depend as to their form on the answers returned, to pass steadily from one point to another till the intended ground is covered, or as much of it as is found desirable.

The *Examinatory* question, as its name implies, is a means of testing whether the instruction has been taken in by the pupils. Its place is at the end of the lesson, emphasising the main points of the subject and clearing up any doubtful points that may arise. Where a subject is continued in a following lesson a few questions of this type would prove a suitable introduction by reviving what has already been done. Questions of this type should be fired off somewhat rapidly as the answers ought to be known. For instructive questions more time should be given as they demand mental effort, and if proper time is not allowed the pupil to collect his thoughts the answers are likely to be more or less unsatisfactory, or quite random.

Of course, in practice these different kinds of questioning cannot be kept entirely separate; they are used in varying combinations as best suit the purpose in view.

Those who have read Plato's " Meno " will recall the interesting lesson in geometry given in the dialogue between Socrates and Meno's slave-boy. Although it has been often quoted it is sure to be new to many of our readers; so the extract is here given as a characteristic example of the Socratic method of questioning.

Socrates during the discussion states that knowledge is already within us; that "we do not learn, but that what we call learning is only reminiscence." Meno finds it hard to believe this, and asks for proof. Socrates then asks Meno to call one of his attendants, and he will try to prove that what he maintains is true by drawing out certain facts from this untaught slave-boy. "And mark," says Socrates to Meno, "whether he appears to recollect himself or to learn from me."

Socrates. Tell me, boy, do you know what a four-angled space is such as this? (tracing a square on the ground with his stick).

Boy. I do.

Soc. A four-angled space then has all these four lines equal?

Boy. Certainly.

Soc. Has it not also these lines through the middle of it equal?

Boy. Yes.

Soc. Could there be a space like this, larger or less?

Boy. Certainly.

Soc. Now, if this side were two feet, and this two, how many feet would there be in the whole? Consider it in this manner. If, on this side, the space were two feet, and on this only one foot, would the space be other than of two feet once told?

Boy. It would not.

Soc. But since it is two feet on this side likewise, is it any other space than of twice two feet?

Boy. No.

Soc. It is then a space of twice two feet?

Boy. Yes.

Soc. How many feet are twice two?

Boy. Four feet, Socrates.

Soc. Cannot there be another space the double of this in size, but of the same kind, having like this all its sides equal?

Boy. Yes.

Soc. Of how many feet will it be?

Boy. Eight.

Soc. Come now, endeavour to tell me, how long will each line of this space be? Now of this space the line is two feet. What will be the length of the line of the space double the size?

Boy. It is plain, Socrates, that it will be double the length. (Socrates prolongs a side of the square to four feet in length.)

Soc. Now, from this line you say that there will be a space of eight feet, if there be four such lines ?

Boy. I do.

Soc. Let us then draw from it four equal lines. (Completes the square, Fig. 1.) Would this space be any other than that which you say is of eight feet ?

Boy. Not at all.

Soc. Are there not in this space these four spaces, each of which is equal to that of four feet ?

Boy. Yes.

Soc. How large is become the whole space ? Is it not four times as large ?

Boy. Yes.

Soc. Is that two-fold which is taken four times ?

Boy. No, by Jupiter.

Soc. How many fold ?

Boy. Four-fold.

Soc. From a line, therefore, double in length there is produced a space not two-fold but four-fold.

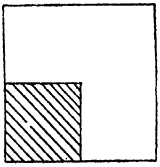


FIG. 1.

Boy. You say true.

(Finding that the four feet line gives too large a square, the boy, after further questioning, suggests a line three feet long.)

Soc. If then it be three feet, we will add the half of the first line to it, and now this will be three feet. For these are two feet, and this is one foot : and in the same manner, these are two feet, and this is one ; and this space becomes such as you say.

Boy. It is so.

Soc. If then this line here be three feet, and that three feet, the whole space becomes thrice three feet.

Boy. It appears so.

Soc. And how many feet are thrice three ?

Boy. Nine.

Soc. But how many feet ought the doubled space to be ?

Boy. Eight.

Soc. Hence from a line three feet long there is not to be drawn the space of eight feet.

Boy. There is not.

Soc. But from how long a line ? Endeavour to tell me exactly.

thought he knew but did not. After much questioning he still did not know, but he no longer thought he knew. Then, after the boy's misconceptions had been cleared away, the way was prepared for a proper understanding of the matter dealt with. In dealing with self-opinionated people, Socrates often made his preliminary questioning rather irritating, by drawing from them definitions and arguments which he afterwards used against them to their own confusion. It is an excellent method of convincing people that they are not quite so wise as they imagine; but with children this is not very necessary, as a rule they are fully conscious of their ignorance. In their case the Ironic method, so frequently used by Socrates, is quite unsuitable. Unless it is done with the most obvious good humour, the result will generally be the resentful silencing of the class on their answers being turned against them. Irony is dangerous, so far as children are concerned.

It will have been noticed that the direct question, requiring Yes or No as answer, is very freely used. This is generally condemned as a method of educational questioning, because the chances are equal between right and wrong even if the pupil guesses only. It will also be seen that Socrates keeps the dialogue almost entirely to himself; the listener seems to be participating more than he really is, getting more credit for his replies than he deserves perhaps. The interrogating is so skilfully done, however, that the hearer is kept on the alert all the time.

Let us now take as an illustration a lesson in the manual training room on The Saw, for example. Provide yourself with a saw and a short end of board.

"Now boys, let us see if we can find out why this hand-saw is suited for the work it has to do. Here is a short piece of timber, I want you to tell me how this board can be divided down the centre without sawing it."

"By splitting it with an axe."

"In what other way?"

"With a mallet and chisel."

"Would it be cut exactly where we wanted it cut?"

"No. It would split along the grain."

"Now, suppose we wished to cut it across the middle in this other direction, how should we proceed?"

"With the mallet and chisel again."

"But we cannot split it this time. How then?"

"By cutting vee-shape grooves across both sides."

"Should we then have square ends to the pieces?"

"No. They would need chiselling or planing square."

"Perhaps you can now say what a saw does better than any other tool?"

"It separates wood without much trouble."

"What do you mean by trouble?"

"Work—labour."

"What else will be saved besides labour?"

"Time: it will do the work more quickly."

"Anything else saved?"

"Yes; wood."

"So that by using a saw we save ——?"

"Labour, and time, and timber."

"Now tell me what a saw is?"

"A tool with teeth."

"Yes, but so is a garden-rake."

Questions are plied till some such definition as this is obtained: A saw is a tool for dividing material in any direction and with the least possible waste.

"Which cuts better, a saw with a thin blade or one with a thick blade?"

"A saw with a thin blade."

"Why?"

" Because it will make a narrower cut."

" Well, if a thin blade is so much better than a thick one, why don't we have the blade thinner still ? "

" It would break."

" No, it need not : steel can be made very bendable. Try again."

" It would always be bending up."

" Yes, and what harm would there be in that ? "

" We could not get on with the work so well."

" So that even a thin saw blade must have what quality ? "

" Stiffness enough not to bend much when in use."

It is unnecessary to continue further. Of course all this could have been told to the pupils in a few brief sentences. Are we justified in asking all these questions in order to draw out what is afterwards so self-evident ? Yes, emphatically. So far as may be, a lesson should be a voyage of discovery to the children. They should be made to think both what to answer and how to answer, not merely to assent or dissent to what you say. Again, if you simply tell facts and give reasons for them the matter is not so likely to be retained as it is when those reasons have to be sought for in the pupils' own minds. Generally speaking, what is taken in with little effort is just as easily forgotten. It is the child's own effort that stamps the deeper impression. One of the chief functions of education is to turn out able thinkers; this can best be done by training children to think for themselves.

Mark what has occurred in the example just given. First, the questions are not haphazard. The teacher has kept in mind certain aspects of the lesson which he wishes to emphasise—the purpose of the saw; its superiority to all other tools to accomplish that purpose; and the natural limit offered to still greater perfection in the way of a finer saw-kerf. The questions are directed to bring out these points in proper sequence. Should the replies lead away from the desired aim it is for the questioner to lead back again into the right channel.

The art of framing questions skilfully is by no means an easy one. The fewer the words employed the better, so long as the language is clear and simple. There should be no ambiguity; the question should admit essentially of one correct answer only. Each succeeding question should follow naturally from what has preceded, and it should not hint at what the answer ought to be.

Children enjoy finding out things for themselves, and under proper direction they should be encouraged to do so. But of course there are limits to this—" art is long and time is fleeting." Some things must be told.

There is another kind of questioning that may as well be mentioned before closing this section, and that is self-questioning. In teaching it is so very easy to get into a groove, that there is constant need of revising and improving our methods of instruction. It is by no means an unwise plan to look with suspicion on any pet method or theory we have held for any considerable time. But do not give it up unless you have a better to take its place; and do not too readily take it for granted that somebody else's way *is* better—for you. The teacher who ties himself down to work by rules and maxims will not lack guidance. By all means make yourself acquainted with whatever dicta the literature on teaching affords, but always remember that " the letter killeth, the spirit giveth life." We have all of us got bents and temperaments peculiar to ourselves, and we cannot perhaps get far away from our own particular bias with impunity.

NOTES OF LESSONS

The briefest Notes of a Lesson on any subject would be simply to write down the headings of the steps in the order in which they would be used in giving the lesson. A better and more complete way, the time-honoured method of the text-books on School Management, is to proceed as follows.

We will suppose that a lesson on The Grindstone is to be prepared for a class of "first year" boys. Divide your Notes of Lesson paper into two columns as under, and then settle upon the heads under which you will take the lesson. The Method column constitutes the teaching plan.

THE GRINDSTONE

MATTER	METHOD
I. *Introduction : Purpose*	
(*a*) The need of a grindstone in the M.T. room.	(*a*) By questioning show that plane-irons and chisels cannot for long be maintained at the original angle by means of the oilstone alone.
(*b*) It shapes metal quickly and so saves time and labour.	(*b*) Educe that the grindstone quickly removes what could only be worn away on the oilstone by long and tedious rubbing.
II. *How it acts.*	
(*a*) The grains of sand plough into the hard steel.	(*a*) Class to examine a newly-ground tool. What can be seen? How are these scratches on the ground portion made?
(*b*) The kind of stone used for grindstones. A sharp sandstone, not too hard, is quarried at Bilston, Staffordshire, which is very good for grindstones.	(*b*) Would a perfectly smooth stone answer the purpose? Why not? Tell where the stone is quarried.

MATTER	METHOD
(*c*) Both stone and tool are worn away, the stone more than the steel.	(*c*) What is the sediment at the bottom of the trough? Which wears away more, the stone or the steel? Why? Compare the relative surfaces.
III. *Why water is used on the stone.*	
(*a*) Friction creates heat.	(*a*) What happens when we rub our hands together briskly? Friction or rubbing, therefore, creates—?
(*b*) Temper of tool spoiled by overheating.	(*b*) Ask what would occur if tool were ground without using water on the stone. If the children know what is meant by tempering, draw from them what is likely to happen. If not, explain briefly.
(*c*) The water prevents the surface of the stone being clogged with worn material.	(*c*) Show how the stone loses its cutting power when kept dry, owing to the particles of stone and steel clinging to it.
IV. *Friction.*	
(*a*) Friction desirable on the rim of the stone, but not at the axle.	(*a*) Does the water used on the stone cause more friction, or does it lessen it? Where do we try to lessen friction?
(*b*) Further illustrations of advantages and disadvantages of friction. " Side-slip " when cycling is caused through insufficient friction of the tyre with the ground.	(*b*) Other examples where friction is desirable may be asked for; and where it is not desirable. Compare, for instance, the grindstone with the wheels of a bicycle. Show that in both cases friction is necessary on the rim, but not desirable in the bearings. What causes " side-slip " when cycling? What is done to lessen friction at the bearings? Why?

It is a good plan to have a notebook in which to jot down rough notes, extracts, etc., that are likely to be useful for teaching purposes. A course of general reading provides an abundance of good and interesting matter that may be utilised with advantage in the classroom; and unless a note is made of it at the time the reference is either forgotten or cannot be traced when wanted. A book of the kind suggested is very helpful when compiling Notes of Lessons.

The order of presentation of the subject matter being of great importance—good arrangement renders acquisition easier and affords systematic training in the habit of exact and orderly thinking so valuable to the pupils—the reader is asked to consider very carefully the remarks which follow on the steps in teaching. It is to Herbart, the German educationist and philosopher, and his followers that credit must be given for this noteworthy contribution to pedagogic theory.

HERBART'S FORMAL STEPS

By the Herbartian method of dealing with the subject matter of a lesson, the teaching scheme is divided into five stages—"the formal steps" or "Herbart's five steps." These are (1) Preparation; (2) Presentation; (3) Illustration or Comparison (Association); (4) Generalisation; (5) Application.

The scheme is based upon the principle that the mind deals with new ideas in so far only as they are connected with the ideas already present in the mind. It may be applied to any lesson, or to a series of lessons. In the latter case one lesson may take in only the first two steps for instance, leaving the further steps for future lessons. Something will now be said about the aim of each step.

(1) Preparation.—This does not refer to preparation of the lesson by the teacher but to the preparation of the

minds of the pupils for the subject matter of the lesson. The first thing to do, after mentioning the subject of the lesson or explaining its aim, is to find out what the scholars already know, so that the new matter may be connected with their past experience. This preliminary questioning is most important. It is of little use attempting to build on a foundation which is not there. We have all at some time or other entered a room where business or an address was in progress and can recall the sense of bewilderment at first felt as to what it was all about. Only when we have connected what is being said with what we are already acquainted with, can we follow with any degree of intelligence the matter under consideration. When the new ideas join on to our old ones we are ready for them, and not before. The preliminary questioning to find out just how things stand, also brings into activity all the pupils' ideas related to the subject and focusses them on the new material. The mind throws out feelers among the new ideas in order to fit them into its past experience.

Most of the lessons given in the manual training room will deal with objects in the room such as tools, timbers of different kinds, or other materials. The preparation in this case may be an examination of the object by the boys, or showing specimens or illustrations to them. The teacher should prepare anything of this nature, that will be needed during the lesson, so that no time may be lost.

(2) Presentation.—Having brought into play groups of ideas favourable to the reception of the new ones we wish to introduce, and so far as possible created an appetite for them, we present the new ideas as clearly and interestingly as we can. Interest is the key which unlocks the mind; to secure that is to ensure success.

Sequence is important. Do not have to hark back, like the clumsy teller of a story, to what should have been introduced before. As each new point is brought out concentrate the attention of the class upon it exclusively, allow it to soak into their minds, and then spread out the attention again to the bearing of the new point upon the whole mass of ideas. That is, see that all the details introduced dovetail into their proper places in the mental structure you are building up. There is thus an ebb and flow of attention from the details to the whole; an alternate analysis and synthesis.

(3) COMPARISON.—In the first step we called up all knowledge likely to aid in the assimilation of the new; next the new was presented; the third stage is to compare the new ideas gained with other ideas having some relationship to them. The more we surround an idea with suitable companion-ideas the better it will stay in the mind. Examples and illustrations are valuable here and will serve this end.

(4) GENERALISATION.—This stage is a summing up of what has gone before, and arriving at a sound judgment of its underlying meaning. The greater the number of particular cases we have examined, the truer will our generalisation be. We are most of us in everyday life apt to insert the " therefore " of our conclusions from a too meagre consideration of the particulars or an insufficient number of them. The children's range of experience is much more limited than the teacher's; it will be necessary therefore to exercise caution so as not to generalise outside this range. It is at this point in the lesson that we draw our moral, make our " law," or arrive at a suitable definition.

(5) APPLICATION.—In one sense the lesson is finished

with the fourth stage. No thought is quite complete, however, that does not lead to action. The general conclusions arrived at should, if possible, be put into actual practice. Examples should be worked, or a test of some sort given to show the pupils' grasp of the subject. Where the nature of the lesson does not permit of this, the application will be made an intellectual one.

. . . . . .

The Herbartian formal steps furnish the best practical teaching principles available to us. The value of the method, of course, depends on the manner in which it is worked; in unskilful hands the process may easily become mechanical. Like the painter's colours it requires mixing with brains.

The real value of the lessons on the toois and materials of the manual training room, lies in the manner in which the information is given rather than in the worth of the knowledge itself; in the mental training afforded rather than in the facts learned. Let us again repeat that good arrangement of the matter is of prime importance. Nothing will more conduce to successful teaching, and to the intellectual satisfaction accompanying it, which is the teacher's keenest pleasure and reward, than careful preparation beforehand of the lessons, and more especially of the best methods of guiding and controlling the thoughts of the class during instruction. The order of the teaching steps demands special thought and skill, and implies full consideration of the principles underlying the art of teaching. Free use should be made of specimens, illustrations, experiments, and of blackboard sketches and summaries. The teacher should constantly exercise his discretion and not slavishly copy the methods of others. He should be willing to learn from others, but not without examination as to the merits and suitability of the new way. Everything should be reviewed in the light of his own judgment and experience, and accepted, modified, or rejected accordingly.

DIRECTOR OF INDUSTRIES
Bengal

CHAPTER VIII

TREES AND TIMBER

MATTER FOR OBSERVATION LESSONS

"I shall speak of trees as we see them, love them, adore them in the fields, where they are alive, holding their green sunshades over our heads, talking to us with their hundred thousand whispering tongues, looking down on us with that sweet meekness which belongs to huge, but limited organisms,—which one sees in the brown eyes of oxen, but most in the patient posture, the outstretched arms, and the heavy-drooping robes of these vast beings endowed with life, but not with soul,—which outgrow us and outlive us, but stand helpless,—poor things!—while Nature dresses and undresses them like so many full-sized, but under-witted children."—O. W. HOLMES.

THE pupils should be led to study the living trees—so different from the dead sections, the brown and faded leaves and the blackboard sketches by aid of which we sometimes try to induce a love of nature—in order that they may have joy in its beauty of form, the wonders of its growth, and the subtle uplifting that comes of delight in open fields and greenwood trees.

The tree should be regarded not from the mercantile point of view alone, but also from the æsthetic and health-giving aspects, and with due admiration of its general economy and adaptation to its environment, however cramped the latter may be.

Some teachers may be placed so fortunately as to find an abundance of material at hand, while others will need all their enthusiasm to enable them to draw from solitary local specimens, growing perhaps at the end of a crowded court or struggling for existence in the limitations of a backyard, all the little lessons they would have their pupils learn. In any case it is to the tree itself that the pupils must go really to learn what can never be efficiently taught by dead and labelled specimens. Where it is possible for them to see many varieties of trees the pupils can be taught to know them and to recognise their differences.

Such points as the general outline of the tree and the different shapes of the leaves can be noted by the pupils by aid of sketches or by means of paper cut to similar forms. The leaf, flower, and fruit should each come in for notice as well as the bark, shape and general trend of the branches, trunk, and other details.

A diary may be kept by the pupils in which to report the first sign of the leaves opening in the spring, the coming of the blossom and the ripening of the seed, as well as other events they may notice in the life of the tree. A rough map of the district can be made and the names of any important trees placed upon it. Leaves may be gathered and preserved, as described below, or their shapes may be recorded by means of blue print photographs, which are easily made and delighted in by the pupils. Many of the scholars will have already learnt something of the development of the plant from the seed, either in their class-work, or in their gardens at home; this may be suitably supplemented by the growing of young plants from acorns and other seeds. After the pupils have come to love the trees and intimately observe them, the true value of a piece of wood, so wonderfully constructed in nature's silent workshop, cannot help forcing itself upon their minds.

Much useful and interesting subject matter will be found in the uses to which the various woods are put.

The pupils should be got to connect the characteristics of the various woods with these uses. The brief notes in this section are suggestive for the purpose. Thus, for instance, knowing that beech is used for planes it may be drawn from the pupils that closeness of texture, evenness of wear, and durability are necessary for such a tool, these qualities are possessed by beech.

The diligent reader will constantly come across interesting facts connected with trees. These he will gather in a notebook, if he be wise, for future reference. At the end of this chapter we include a few extracts from writers on the natural history of trees, feeling sure they will stimulate the reader to search further among such books as Gilbert White's "Natural History of Selborne."

PRESERVING LEAVES.—A collection of leaves, mounted and framed, will make an interesting ornamental feature when displayed on the walls. The leaves selected for preservation should be well formed specimens typical of their kind. These can be pressed between the leaves of a book, and if chosen when mature will keep their colour well so long as they are not exposed to the light during the drying process. The book must be heavily weighted and the leaves allowed to remain in it some weeks, so that the drying may be thoroughly done. To mount them, all that is necessary are a few touches of gum to attach them to a plain cardboard, the leaves being pressed, when put in the frame, between the cardboard and the glass and the names of the leaves printed beneath them.

The shapes of leaves can be successfully photographed without a camera by placing them between plain glass and a piece of sensitized paper, and exposing them to the sunlight. The print is afterwards toned in the ordinary way. "Blue-prints" on ferro-prussiate paper are most easily managed as they can be fixed by merely washing in water. By taking a negative impression on a plate and then using the plate for printing on sensitized paper, a positive photograph of the leaves may be obtained.

FORESTS—VALUE AND PRODUCTS

VALUE OF FORESTS.—The beauty of the land is much increased by trees and forests. Imagine the very different feelings one would have, for instance, in taking a walk on a hot day over bare stony heath, and a walk on a similar day along a road well lined with trees or through the shady paths of a wood, enjoying the scent of pines, the rustle of the leaves, and the song of birds. And if our surroundings thus influence our feelings, it seems probable that a people brought up amid beautiful country and charming woodland are likelier to be blessed with contentment and peace of mind than if they dwelt in black and barren localities. Trees act as shelter for both homesteads and pasture. They give shelter, too, for birds which keep down insects and other farmer's pests. They help to purify the air. The roots of the trees prevent erosion, or the wearing away of the soil owing to heavy rainfall. In the Landes in France, over 100,000 acres of land have been reclaimed by planting the pinaster pine and so arresting the drifting sand which formerly made it worthless.

"Conifers enrich the soil by the fall of their leaves, so that they are often grown to prepare the soil to sustain the greater demands made by the broad-leaf trees which can afterwards be profitably planted.

To the natural forests of the past we are indebted for our rich coal measures.

The enormous demand for timber throughout the civilised world has caused the ruthless cutting down of large areas of forests, at the same time no care has been taken to replace more than a very small portion of the trees used. This, unless checked, will ultimately lead to a timber famine, and some authorities believe that this may begin within fifty years. In America and in Sweden something is being done to check this rapid depletion of forests. Among the devices for this end is an Arbor day, on which the school children have a tree planting festival.

Great Britain has paid over £25,000,000 per annum for some years for imported timber. A large proportion of this might, it is said, be grown at home if about one-third of the 21,000,000 acres now lying waste and out of cultivation were put to this purpose.

The area covered by forests and woodlands is as follows:—United Kingdom 4 per cent., France 18, Germany 26, Sweden, Canada, and United States about 40 per cent., of the total area.

BY-PRODUCTS OF TREES.—In addition to providing timber for various purposes a number of other products are obtained from trees.

Turpentine is distilled from the resinous sap of several conifers. The crude turpentine is obtained by making an incision at the base of the trees and collecting the sap that exudes and allowing it to harden. Most of the world's supply is obtained from the North American forests, only a small amount coming from the forests of Europe.

American turpentine is obtained from *Pinus Australis*; French from *Pinus pinaster*; Russian from *Pinus Sylvestris*; and Venice turpentine from *Pinus larix.*

Resin or rosin, is the residuum after distilling crude turpentine to obtain the oil or spirit of turpentine used in making paint and also in medicine. Resin is used in making paper, varnish, soap, and sealing wax. The resin of the Kauri pine of New Zealand is used for making the finest varnishes.

Tar is made from wood by allowing it to smoulder under a cover of turf or earth which excludes the air. Tar is also made from wood in iron retorts; the product in this case is thinner than that obtained by the first method.

Wood-tar is used for preserving wood, rope, and felt, and also in medicine. From wood-tar are distilled *Creosote*, *Paraffin*, and *Pitch*.

Charcoal, used for fuel, results from the process of obtaining tar from wood as above. In making charcoal for gunpowder, the wood is heated in iron cylinders to prevent the introduction of grit. Charcoal has a questionable use in the preparation of "cocoa" powder, the charcoal is then prepared at a lower temperature to give it a brown colour. Charcoal is also used as a deodorant, for surrounding cold storage chambers, it being a bad conductor of heat, and for crayons.

Lamp black is obtained by the imperfect combustion of oil and resin, and is used for painting.

Wood-pulp is used for paper making. Two processes are in use to make wood-pulp, (1) by grinding the wood, (2) chemical disintegration; the last method produces the best paper. It has been estimated that the daily requirements of a large London paper represent about ten acres of an average forest.

Rubber is obtained from tropical trees belonging to several species. The crude produce of the trees has to be vulcanised so as to harden it without destroying its elasticity. The finest rubber is Para rubber from the Amazon valley.

Tree Oils.—Palm oil is obtained by crushing the fruit of the oil palm, and is used in making soaps and candles.

Eucalyptus oil is distilled from the leaves of the Australian Eucalyptus tree.

Castor oil is obtained from an Indian plant by crushing the seeds.

Olive oil is expressed from the dried fruit of the Olive (*Olea europœa*), and is used in medicine, for salads, also for lubricating oilstones.

Dyes.—*Logwood* and other dyes are obtained by cutting the wood into chips and treating them with some solvent.

Cork is obtained from the bark of the cork tree (*Quercus ilex*), grown in Spain, and is used for very many purposes. Ground cork is used in the manufacture of linoleum.

Bast, from the inner layers of the bark of the lime tree, is used to form Russian bass or bastmats. It is also used in gardening for tying up plants. Flax, hemp, and jute are bast fibres of different plants.

Potash, caustic potash, and pearl ash are got from wood ashes after burning lumber from the saw-mills.

Tannin.—Oak bark was at one time the bark mostly used in the process of tanning leather. The barks of larch, hemlock, spruce, and other trees are used as substitutes. Most of the modern leather is tanned without the use of bark, chrome being used in its place.

Ink is made from crushed galls boiled in soft water, with the addition of ferrous sulphate.

THE PARTS AND GROWTH OF TREES

OUTLINE OF TEACHING METHOD.—Even the youngest boys that attend our Manual Training centres will be able to supply a list of the chief parts of a tree. Having drawn the names of these parts from the class they should be clearly written on the blackboard in letters large enough to be plainly seen by all. Thus we shall have :—

1. Roots.
2. Trunk or Stem.
3. Branches.
4. Twigs.
5. Leaves.
6. Flowers and Seeds.

The last item, flowers and seeds, may require some little questioning on the part of the teacher before being drawn from the pupils, as in many cases the flowers and seeds are so inconspicuous as to avoid notice ; but they play a very important part in the life of trees.

When the parts of a tree have been named, the next thing is to give the pupils an understanding of the meaning and functions of those parts in a series of brief lessons. Some teachers may prefer merely to add a little to what has been written on the blackboard and thus give a broad general view of the relation these parts bear to the whole, leaving the more detailed account for future lessons. Others may deal with each item separately, giving a lesson on the roots at one time, the leaves at another, and so on. In the first case the blackboard notes will read :—

1. *Roots.*—Hold the tree in the ground, take in food from the soil.

2. *Leaves.*—Build up the tree by food taken from the air.

In the second instance, the blackboard notes will be more detailed, based somewhat on the lines of a general summary of the matter given below. In either case it is desirable that the teacher provide himself with examples of what he describes whenever possible.

Failing an actual specimen, freehand sketches, diagrams, and other pictures will help to impress the lesson. The illustrations should lead the pupils to further and closer observation of the things discussed and not merely to passive interest. Starting at the bottom of the tree we have :—

THE ROOTS.—The roots not only securely fix the tree in the soil but partly feed it. The roots consist of stems and branches which increase in size and strength as the plant grows. New roots are developed as the plant increases in size. The lengthening of the roots takes place by the growth of cells at their extremities, these growing cells being protected by a thimble-like cap (Fig. A), which is forced through the ground in the direction of growth. This growth enables the roots to withstand a greater strain, and, more important still, to gather a larger amount of nourishment. As it is from the soil that this nourishment is drawn let us see of what this earth consists. Water is necessary to the life of a plant, it cannot thrive in dry soil. If damp earth be examined very closely, it will be seen to consist of small particles of matter surrounded by thin films of water. Now water, as everyone knows who has seen a piece of sugar or some salt melt away in a glass of water, has the important property of dissolving certain solids and thus making solutions. It is solutions made in this way that the tree takes in by means of its roots. It is evident that the kind of solutions the tree needs will be determined by the chemical composition of the tree

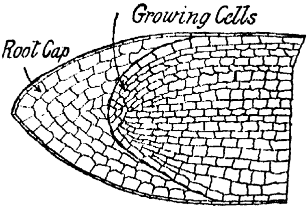


FIG. A.—EXTREMITY OF A ROOT.

itself. When analysed by chemists a tree is found to be built up from these ten elements, carbon, hydrogen, oxygen, nitrogen, sulphur, potassium, phosphorous, calcium, magnesium, and iron. All of these except the first can be obtained from the ground by the roots. Carbon, as we shall see later, is obtained by the leaves from the air. These nine plant formers do not exist in the ground as simple elements but as chemical compounds, and it is these which are dissolved by the water and taken up by the roots. The process of taking up is not like the taking up of water by a garden syringe, but more complex. The process can be demonstrated by putting a solution of sugar into a jar and then dipping a thin bladder containing pure water into it. After a certain length of time it will be found that some of the sugar solution has found its way into the pure water, as can easily be proved by tasting it. This process, by means of which there is an exchange between two different solutions placed on each side of a thin membrane, is termed *osmosis*. If this is how a root takes up its nourishment where shall we find the thin membrane? Examined under a microscope every part of the tree is seen to be built up of small boxes or cells of various shapes. The walls of these cells consist of *cellulose*, and the cells contain a *cell sap* which in the living cell is known as *protoplasm*, because it has the vital property of growing. (Proto = first, plasma = anything formed or moulded.)

The outer parts of the smaller roots (cortex) are composed of cells which have grown into the particular shape shown in Fig. B, and it is these particular cells, seen as root hairs, which draw the moisture from the earth. Their walls are the thin membranes having the cell sap in their inner side and the films of water on their outer side. During the process of osmosis the roots exude a slightly acid secretion, which further helps to dissolve the compounds existing in the earth. In this way a piece of limestone found under the roots of a growing plant will have etched on its surface the marks of the roots in contact with it. The nourishment taken up by the roots is known as "crude sap" to distinguish it from the "elaborated sap," the product of the leaves.

THE LEAVES.—We have already stated that there is one element (carbon) needed by the tree that is not supplied by the roots; to get this is the work of the leaves, which we will consider next.

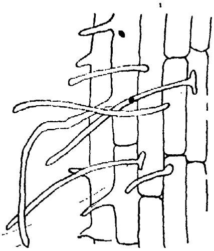


FIG. B.- ROOT HAIRS. Much Enlarged.

Perhaps the most noticeable fact about leaves is their green colour, this being due to the presence of a substance named Chlorophyll (Chloros = green, and phullon = a leaf), which plays a most important part in the life of a tree. It is not sufficient for the tree that it shall have a supply of the elements we have named; they must be built up, step by step into organic compounds, till in the end the living stuff called protoplasm is formed. This building up of the materials supplied by the roots and leaves into compounds is done by the living

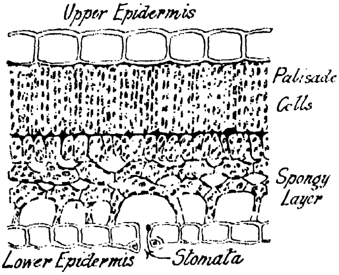


FIG. C- SECTION OF A LEAF.

tree under the influence of sunlight with the co-operation of Chlorophyll. As we have already seen the roots supply mineral matter and water for this purpose, these travel through the stem, along the branches into the leaf stalks, and so into the leaves, while the carbon dioxide is obtained by the leaves directly from the air. The peculiar structure of the leaves, as shown in Fig. C, enables them by means of a large number of small mouths or *stomata* (mostly found on the under side of the leaf in order to prevent them from being choked by small particles of dust falling upon them) to absorb some of the carbon dioxide, a small percentage of which is found even in the purest air. This is combined in the leaves with the materials obtained by the roots to form the compounds needed for the life of the tree. Thus the leaves are the laboratories in which nature silently manufactures from earth, air, and water the " elaborated sap " which afterwards builds up every part of the tree. All the oxygen found in the carbon dioxide is not needed for compound-building and the surplus is liberated, thus giving rise to the statement that trees breathe out oxygen. The breathing process is quite a separate one, as we shall see later. The greater part of the tree is built up from the carbon obtained by the leaves and oxygen and hydrogen obtained from the water. The relatively small amount of material obtained from the soil can be seen by thoroughly drying a small bush with the leaves on and burning it. The ash that remains is practically all that the plant obtained from the soil; the rest has passed back into the air from which it originally came.

TRANSPIRATION.—At all times the leaves are giving off a water vapour. This may be easily demonstrated by putting the stalks of some leaves through a hole in a card into a glass of water and then covering the leaves by another inverted glass. After some hours small drops of water will be found adhering to the upper glass. This giving off of water vapour is termed *transpiration*. The process is a useful one, because it allows the leaves to deal with a greater quantity of water than would otherwise be the case and so obtain sufficient mineral matter for building up the compounds. For the crude sap only contains a very small proportion of the needed mineral matter compared with its bulk.

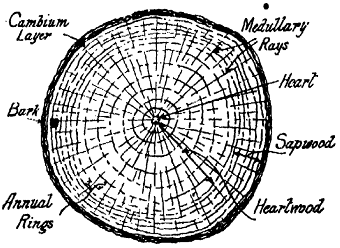


FIG. D- SECTION OF A TREE

THE BREATHING OF PLANTS.—Plants, like animals, are constantly taking in oxygen and breathing out carbon dioxide. In the case of plants, however, the amount of carbon dioxide breathed out is more than compensated by the amount absorbed during the feeding process, and so the plants are correctly known as air-purifiers.

THE TRUNK.—The trunk or bole of timber trees and the larger branches supply us with wood. The botanist divides trees into three classes, which are here given in their order of ascending development. *Acrogens* or summit growers, of which the tree fern of New Zealand is an example ; *Endogens* or inward growers, such as the date palm ; *Exogens* or outward growers, such as the Oak, Northern Pine, etc. All the timber-producing trees belong to this class.

If we make a horizontal cut through the trunk of an oak tree and look at the section so obtained, we find the following parts, commencing from the centre, Fig. D.

1. The heart, pith, or medulla.

2. A number of concentric rings, annual rings, each divided into two parts, spring growth and autumn growth.

3. The heartwood, or duramen, consisting of annual rings surrounding the heart and differently coloured from those nearer the bark.

4. The sapwood, or alburnum, consisting of the later and lighter coloured annual rings outside the heartwood.

5. The cambium layer between the sapwood and the bark. This consists of a layer of living cells only existing, as such, in the living tree.

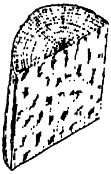


FIG. E.—VERTICAL SECTION Shewing Medullary Rays

6. Bark or Cortex.

7. A number of lines radiating from the pith or medulla and called heart or medullary rays. On examining a vertical section it will be seen that these medullary rays when cut obliquely give rise to the silver grain or figure. Fig. E.

Growth of Trunk.—In timber trees, as we have already stated, the growth takes place by the addition of new material on the outside of the layer of wood immediately under the bark. When looked at through the microscope the structure of the wood of a fir tree is seen, Fig. F, to consist of a number of long thin tubes or cells, tracheides, arranged in a vertical direction, together with a number of cells arranged in a horizontal direction, forming the medullary rays. The size of these tracheides is about $\frac{1}{12}$th to $\frac{1}{16}$th of an inch long and $\frac{1}{1000}$th of an inch in diameter. Communication between the medullary rays and vertical cells is by way of the bordered pits, which are provided with valvular membranes for controlling the flow of sap. The outermost ring of cells, the cambium layer, contains, while the tree is living, protoplasm which enables the cells to grow radially outwards and then divide tangentially, the protoplasm being withdrawn into the new layer of cells formed by

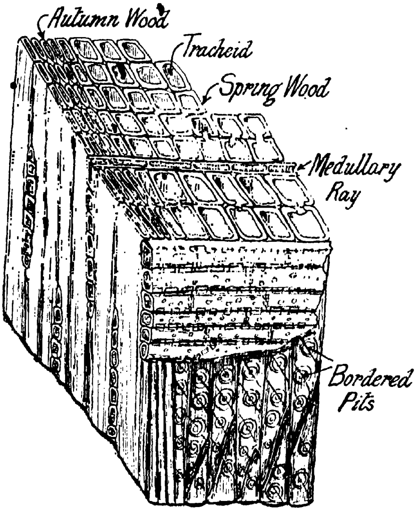


FIG. F-STRUCTURE OF SPRUCE FIR. Much magnified.

the division, and the process of growth continued. In this way, from the cambium during the early summer the so-called spring wood is added to the tree, having cells with thin walls and much inter-cellular space; while later on, after the leaves have been at work for some time elaborating the crude sap layers of new cells are formed having relatively much more wood to cell space. At the same time that the cambium layer is providing new wood it is also forming a new layer of bark underneath the old ones, thus causing the bark to grow with the tree. The medullary rays grow lengthwise along with the cambium. These not only strengthen a tree by their position but form a means by which the sap can reach the inner rings of the heart wood and keep it nourished. The crude sap as we have seen does not contain all the requisite materials for forming new wood or leaves, and for a long time at the beginning of each growing season, food materials stored up in the twigs, branches, and stem are sufficient to supply what is needed for the new growth.

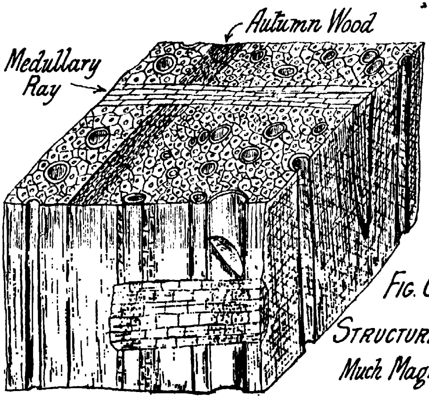


FIG. G—STRUCTURE OF BEECH Much Magnified.

As the cells get older their walls thicken and other changes take place which transform the sap-wood into heartwood. The sap in travelling to and from the various parts of the tree, is better able to traverse the more open structure of the sapwood, its movement varying throughout the year; during the period of greatest growth it is quickest, while in winter the movement is hardly perceptible. In hard woods, such as the beech, oak, etc., the tracheides, of which the soft woods such as pine wholly consist, are less in evidence, their place being taken by true wood fibres and other elements. These wood fibres are extremely dense, this giving rise to the hardness of some of the timbers obtained from broad leaf trees. A diagram of a hard wood showing wood fibres and other elements is given in Fig. G.

The size to which trees can grow is shown by the fact that among the big trees of California a number of specimens reach to over 320 feet above the ground, while they are as much as 90 feet in circumference at the base.

THE BARK.—The function of the bark is to protect the growing wood from extremes of heat and cold, and from the attacks of animals and insects. It generally consists in the young plant of four layers. Commencing from the outside there are (*a*) The epidermis with its cuticle, found only in the young plant; (*b*) a corky layer; (*c*) a green cellular layer; (*d*) bast fibres. Beneath these four layers is the cambium layer, not distinguishable in the dead tree. The uses of the various parts of the bark will be found under the heading of by-products of timber trees.

THE TWIGS.—The arrangement of the leaves on the twigs allows their exposure to the sunlight without shadowing their neighbours. The elasticity of the twigs also prevents the wind exerting too great a pressure and overturning the whole tree.

THE FLOWERS, FRUITS, AND SEEDS.—There is much to stimulate an awakening love of nature in the wonderful adaptations of the flowers, seeds, and fruits so liberally supplied to plants in order that their species may continue. The methods by which the flowers are fertilized by air and by insects; the methods by which the ripened seeds are borne away from the parent plant; the ways in which the seeds are protected in order that they have a chance to survive; all these teem with an interest that appeals strongly to the wonder loving child. All this will be made use of by the wise teacher at the proper time, when the flowers are forming and the seeds ripening. The pupils may be encouraged to look for the seeds that have wings, the seeds that are protected by being encased in prickle-bearing skins or other protective devices. In this way, by getting the pupils to look at the seeds as they grow on the tree and trying to understand their secrets, some may be led to continue far beyond the limits that are possible in the observation lessons given in the manual training room. If the boys already take botany as part of their schoolwork the correlation of it with the woodwork lessons should be an easy matter. We must refer the reader to some of the books on botany given in the list at the end of this section for fuller details.

TIMBER—SEASONING, SHRINKAGE, ETC.

"Knowledge and timber shouldn't be much used till they are seasoned."—O. W. HOLMES.

SEASONING.—This term evidently originally meant simply the exposure of the timber to the drying influences of the atmosphere for several seasons; now the significance of the term has been widened to include the drying of timber in various ways.

Natural Seasoning.—By the natural method of seasoning the moisture is dried out of the wood by placing it in a well ventilated shed, out of the wind and rain, and allowing it to remain there for a sufficient length of time. This method on the whole gives the most satisfactory timber.

Water Seasoning consists in placing the timber in running streams in order that much of the sap may be washed out and the timber afterwards dried. The time required varies according to size of the timber, about three weeks being the time that the wood is allowed to remain in the water. This method is said to diminish the strength of many woods.

Desiccation of timber is a method of seasoning carried out by placing the wood in a room gradually heated up to about 200° Fahr., this temperature being maintained for about three days. The air in the hot room is constantly changed, the moisture laden air being drawn out and fresh warm air driven in.

Sugar Seasoning is the Powell process by which newly felled timber can be immediately treated. The timber is placed in an open tank containing a saccharine solution and the liquid is then brought up to boiling point. After being allowed to cool slowly the timber is taken out and put in hot rooms where it is allowed to remain for some time.

Superheated Steam is used in another method of seasoning, while the Noden-Bretenneau process is known as electric seasoning, and consists in passing an electric current through the timber while lying in a prepared solution, and afterwards drying it in the air.

THE SHRINKAGE OF TIMBER.—As timber shrinks during the drying process, it is well to consider the way in which the alteration of shape takes place. The cells of which wood is made up, in drying shrink considerably more in the direction of their diameter than in the direction of their length, so that a board made up of millions of these tiny cells loses only a negligible portion of its length, but may lose an easily noticeable amount in the other directions. The shrinkage of a log may be explained by using a lady's fan as an illustration, the fan being partly closed and the ribs standing for medullary rays. These it will be remembered consist of layers of cells standing in the tree so that their length is in a radial direction. These medullary rays thus prevent shrinkage of the wood in a radial direction, the shrinkage taking place by the drawing of the medullary rays to each other, like the closing of a fan. To illustrate this small sections of branches and trees can be cut into pieces as shown in the sketches, the cut sections being tied together and put aside to dry, Fig. I. When a board shrinks equally throughout it retains its original shape. But if one side of the board shrinks more than the other the wood is drawn into a slightly curved shape. It will generally be found that the side furthest from the heart contains more moisture and therefore shrinks most, with the result that the heart side of a board is invariably convex.

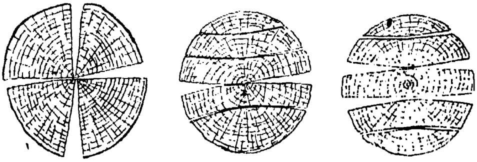


Fig. I.- Cross Sections of Timber, cut while green, after being Seasoned.

Second Seasoning.—Some woods, like oak, are liable to warp and twist every time the surface is removed. With such timbers it is especially desirable that a further seasoning be given after the logs have been cut up into boards, etc. Wood as it stands in the timber yard or wood room gets this additional seasoning. Thin boards should be laid flat and weighted to prevent warping. Joinery is sometimes dry-wedged and stood aside for some months to give it a second seasoning before being glued together. Any member of the work that has suffered in seasoning is replaced.

Figure.—In some woods, such as oak and beech, the value of the wood from an artistic standpoint depends upon the way in which the medullary rays are exposed. By cutting, as shown in Fig. K, along a radial direction a large number of figured boards are obtained. The figure is also termed "silver grain" or "feather."

In timbers where the medullary rays are not visible the marking of the wood depends solely upon the sections made of the annual rings in cutting up the timber. Pitch pine is an example of a timber depending entirely upon the disposition of the annual rings for figure. The method of cutting pitch pine to make the most of this is shown in Fig. L. As the annual rings are never perfectly cylindrical an irregular wavy marking is often disclosed by the cutting.

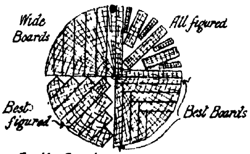


Fig. K.- Oak Log Cut into Boards.

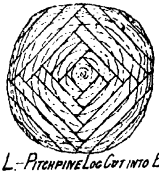


Fig. L.-Pitchpine Log Cut into Boards

A large number of small knots when cut through produce the peculiar kind of figure found on "bird's-eye maple." Each knot or eye corresponds to a twig or shoot in the living tree so that only trees which throw out a large number of shoots can give this peculiar kind of figure. Sometimes the lopping of the young shoots is resorted to for various reasons, and then as a result more shoots are thrown out next season, so that this "pollard" wood is obtained. Oak, elm, and yew will develop in this manner.

Depressions in the annual rings when numerous give rise to a somewhat similar appearance to that given by small knots. Bird's-eye maple is a prominent example of wood growing in this way. Very handsomely figured wood is frequently cut into veneers, so that the most can be made of its natural beauty.

Burrs are excrescences caused by parasitic insects which pierce the bark of the tree. By continuous effort to repair the damage caused by these insects small irregular patches of wood are added until a considerable swelling appears upon the trunk of the tree. When such lumps are cut, very pretty figure is often exposed. For cabinet work the wood so produced sometimes fetches high prices for cutting into veneers.

DEFECTS IN TIMBER.—In selecting timber for manual training purposes the following points should be kept in mind. For young pupils the wood should be of a soft, even texture that leaves a smooth surface when cut across the grain with a sharp chisel. The best quality wood will be cheapest in the end, as there will be less waste. It should be free from knots.

Sapwood is unsuitable for exercises and models on account of its spongy nature. It is difficult to chisel or plane well.

Shakes, whether they be " star " or " heart " shakes, due to seasoning, or " cup " shakes due to the loosening of one year's growth from the next, necessitate some waste of timber and are therefore to be avoided.

Curly grain though, as we have seen, valued for cabinet work is too difficult for young pupils to manage successfully

Irregular coloured patches often denote incipient decay, and should not be present in first-class wood.

Diseases of Timber.—Living trees when past their maturity are liable to be attacked by wet rot. This is specially the case when the trees have been badly lopped so that water soaks into the cut surface and starts decay in the centre of the heart wood. Very old trees are sometimes found with hardly more than a few inches of wood remaining.

Cut timber when insufficiently ventilated and exposed to damp is liable to be attacked by dry rot. This is due to the growth of a parasitic fungus which lives on the wood and destroys its nature, leaving behind a brown residue that can easily be crumbled between the fingers.

Worms and other insects attack wood by boring holes into it, thus eating away its substance. Some of the wood-boring insects are provided with special organs for destroying the timber. The description of these will interest the pupils. Such descriptions are sometimes found in their school readers.

THE FALL OF THE LEAF

Autumn brings the fall of the leaves. In the town the leaves scurry along the roadside and litter the paths, telling that summer has gone. But it is not in town or city that the charm of autumn is felt, it is away in the open—in the fields and woods. Here, where Nature has a freer hand, she rounds off the closing scenes of the changing silent drama with a gorgeous wealth of colour. She lays "a fiery finger on the leaves," the green of summer turns to brown and gold and rich red umber, before they finally carpet the ground and by their decay enrich the soil and so prepare for the next unfolding of the curtain in the following spring.

A series of short Nature Studies entitled "Round the Year," by Prof. L C. Miall, has a most interesting account of the fall of the leaf, and although it is rather long to quote it is too good not to give at length. It may tempt readers to get the book, it is well worth it.

Chill October puts an end to the activity of the leaves of our deciduous trees. They cease to be useful as food-formers, and it becomes important for the tree to get rid of them quickly, and without violence. If the leaves were merely to die in their places, nothing short of a gale of wind would strip the tree, and probably no ordinary gale would suffice. A whole gale, sweeping over a leafy tree, would be attended with loss of twigs as well as of leaves. We see what damage is done by a high wind in summer, when the tree is clothed with firmly adhering leaves. It is much better that the leaf should fall of its own accord in still weather, and return its substance to the soil about the roots, instead of being whirled to a distance. Most of our trees are able to shed their leaves without waiting for them to be torn off, but there are a few unexplained exceptions. The oak and the beech keep their leaves long, especially when young. Are these trees adapted to more sheltered situations than others, or are their branches better able to withstand a strain ? It is well to put these questions, but I must confess I cannot answer them.

Leaves about to fall commonly change colour. The chlorophyll either disappears, or is converted into new colouring-matter. The supply of water and sap is arrested, and both leaf and leaf-stalk shrivel. At the base of the leaf-stalk is an enlargement or cushion, and in compound leaves there is often such a cushion to every leaflet. Though the rest of the leaf and leaf-stalk shrink, the cushion remains plump. Let us stop for a moment to consider what is the special use of the cushion to the active leaf.

It is an organ of movement. By means of the cushion the leaf changes its attitude, inclines its surface to catch the light, droops at night, and in some cases droops when touched. The delicate adjustments by which the leaf sets itself in the best position, both with respect to light or neighbouring leaves, are effected by the cushion. The mechanism of adjustment depends upon the *turgidity* (distention by water) of the cellular cushion. The cells can either absorb water from neighbouring tissues, or give it out, and swelling or contraction follows. There may be swelling on one side and contraction on the other ; the swelling may be temporary or permanent. Swelling on one side causes a leaf-stalk or young stem to incline to the opposite side. Sometimes the cellular tissues of a shoot swell on every side in succession. Then the shoot sweeps round and round in a regular nutation, bowing to every point of the compass in the course of its revolution.

The cushion plays an important part in the fall of the leaf. Here the block takes place which cuts off the supply of water passing upwards from the stem and the roots to the leaf. Here, too, the *separating layer* forms, which at length severs the leaf from the branch.

The separating layer ends by producing a transverse cut through all the cellular tissues of the leaf-stalk, sparing only the vessels and fibres; through these, too, it will ultimately break through. The parting of the cellular tissues greatly increases the ease with which the vessels and fibres snap across. Let us suppose we hold in our hand a slender fishing-rod and switch it to and fro. It sways in gentle and continuous curves, and unless it is loaded, it will not easily break. Now suppose we case the rod in a layer of plaster of Paris an inch thick, which is ringed, or cut completely through, in one place. What effect will the plaster casing have upon the strength of the rod, and upon its power to resist fracture by bending? Our first thought will probably be that the plaster may increase, but cannot possibly diminish, the strength of the rod. Actual trial, however, proves that this very natural supposition is wrong. The cased rod, ringed in one place, will not stand rigorous and sudden bending, but will snap across at the ring. Rigidity everywhere but in one place is highly unfavourable to that nearly uniform curvature which enables the rod to endure a bending strain without fracture. All the bending is now concentrated upon one place instead of being distributed throughout the whole length of the rod. Mechanical engineers have long recognised that abrupt changes of section greatly increase the tendency of axles and shafts to break across.

The separating layer will therefore weaken the leaf-stalk, and predispose it to part at one particular place, although it does not pass through the vessels and fibres, which are the principal means of attachment of the leaf. But this is not all. The separating layer contains a mechanism for producing a positive thrust, which comes in aid of the pull of gravity and wind-pressure, and suffices to part the leaf from the branch, even when it is supported and kept in a perfectly still atmosphere.

PINE AND FIRS

The following, on the pine, is from the pen of John Burroughs, the well-known American naturalist:—

How different the expression of the pine, in fact of all the coniferæ, from that of the deciduous trees! Not different merely by reason of colour and foliage, but by reason of form. The deciduous trees have greater diversity of shapes; they tend to branch endlessly; they divide and subdivide until the original trunk is lost in a maze of limbs.

Not so the pine and its congeners. Here the main thing is the central shaft; there is one dominant shoot which leads all the rest, and which points the tree upward; the original type is never departed from; the branches shoot out at nearly right angles to the trunk, and occur in regular whorls; the main stem is never divided unless some accident nips the leading shoot, when two secondary branches will often rise up and lead the tree forward.

The pine has no power to develop new buds, new shoots, like the deciduous trees; no power of spontaneous variation to meet new exigencies, new requirements. It is, as it were, cast in a mould. Its buds, its branches, occur in regular series and after a regular pattern. Interrupt this series, try to vary the pattern, and the tree is powerless to adapt itself to any other.

Victor Hugo, in his old age, compared himself to a tree which had been many times cut down, but which always sprouted again. But the pines do not sprout again. The spontaneous development of a new bud or a new shoot rarely or never occurs. The hemlock seems to be under the same law. I have cut away all the branches, and rubbed away all the buds, of a young sapling of this species, and found the tree, a year and a half later, full of life, but with no leaf or bud upon it. It could not break the spell. One bud would have released it, and set its currents going again, but it was powerless to develop it. Remove the bud or the new growth from the end of the central shaft of the branch of a pine and in a year or two the branch will die back to the next joint; remove the whorl of branches here, and it will die back to the next whorl, and so on.

When you cut the top of a pine or a spruce, removing the central and leading shaft, the tree does not develop and send forth a new one to take the place of the old, but a branch from the next in rank, that is, from the next whorl of limbs, is promoted to take the lead. It is curious to witness this limb rise up and get into position. One season I cut off the tops of some young hemlocks that were about ten feet high, that I had moved into position for a hedge. The next series of branches consisted of three that shot out nearly horizontally. As time passed, one of these branches, apparently the most vigorous, began to lift itself up very slowly toward the place occupied by the lost leader. The third year it stood at an angle of about forty-five degrees; the fourth year it had gained about half the remaining distance, when the clipping shears again cut it down. In five years it would probably have assumed an upright position.

A white pine of about the same height lost its central shaft by a grub that developed from the egg of an insect, and I cut it away. It rose from a whorl of four branches, and it now devolved upon one of these to take the lead. Two of them, on opposite sides, were more vigorous than the other two, and the struggle now is as to which of these two shall gain the mastery. Both are rising up and turning toward the vacant chieftainship, and unless something interferes, the tree will probably become forked and led upward by two equal branches. I shall probably humble the pride of one of the rivals by nipping its central shoot.

In one of my Norway spruces I have witnessed the humbling or reducing to the ranks of a would-be leading central shoot. For a couple of years the vigorous young tree was led upward by two rival branches; they appeared almost evenly matched; but on the third year one of them clearly took the lead, and at the end of the season was a foot or more in advance of the other. The next year the distance between them became still greater, and the defeated leader appeared to give up the contest, so that a season or two afterward it began to lose its upright attitude and to fall more and more toward a horizontal position; it was willing to go back into the ranks of the lateral branches. Its humiliation was so great that it even for a time dropped below them; but toward midsummer it lifted up its head a little, and was soon fairly in a position of a side branch, simulating defeat and willing subordination as completely as if it had been a conscious, sentient being.

CHILDREN'S THOUGHTS ABOUT TREES

Children instinctively and without teaching ascribe emotion, sense, intelligence, morality to trees. They have arms and legs;

sap is their blood or tears ; leaves are their dress, which they feel ashamed to lose ; their bark is skin ; they are personified ; fall in love with each other ; are lonesome if trees near them are felled ; make shade, if they are kind, just for the children ; like to have them around ; spread out their arms in benediction or shelter ; watch over the house ; miss the children, and perhaps weep for lonesomeness, if they do not play round them ; are fast friends of the birds, who perhaps sing to put the leaves to sleep, and are welcomed back in the spring ; trees feel honoured and joyous if the birds build their nests in them ; hold out their hands when they are passing to invite them to alight. Trees talk to each other and understand the thoughts and language, at least of the trees of the same species, though oftener of all kinds. They sometimes laugh loudly ; sway their branches as if to shake hands ; say good-night. The rustling of their leaves is whispering of or to the fairies, who live in them ; " the wind blowing through branches is leaves singing their babies to sleep ; trees of the same kind like to be planted near each other, for if an elm is planted near a maple, it would be like putting an American girl with a little Dutch girl " ; but trees can understand the children, and the children the trees. A child of six, walking in the woods, looked up and said, " Oh ! I am only going a little way," because the leaves asked her. To one of ten, if the wind blew mournfully, the leaves said, " I am sad " ; if it blew hard, " I am mad." To a boy of ten, trees get angry with the wind, and scream, scold, and slap it. To one of eleven years, God comes into the trees at times when the clouds touch their tops. The spirit of trees goes to heaven. They sing to moon and stars. Trees are very often hugged, greeted after a long absence, thanked for giving shade. Trees that cast no shadow are selfish ; crooked trees, those that bear no fruit, or are bitter, poisonous, prickly, malodorous, are bad. Children are pained and sometimes exasperated at the cruelty of trimming trees. Dense forests soothe, hush, and awe the soul and feel " like church."—" Adolescence," by G. STANLEY HALL.

TREES AND THE STRUGGLE FOR EXISTENCE

Dr Alfred Russel Wallace in "Darwinism," gives the following interesting example of the struggle for existence among trees:—

Mr Darwin observed, on some extensive heaths near Farnham in Surrey, a few clumps of old Scotch firs, but no young trees over hundreds of acres. Some portions of the heath had, however, been enclosed a few years before, and those enclosures were crowded with young fir trees growing too close together for all to live; and these were not sown or planted, nothing having been done to the ground beyond enclosing it so as to keep out cattle. On ascertaining this, Mr Darwin was so surprised that he searched among the heather in the unenclosed parts, and there he found multitudes of little trees and seedlings which had been perpetually browsed down by the cattle. In one square yard, at a point one hundred yards from one of the old clumps of firs, he counted thirty-two little trees, and one of them had twenty-six rings of growth, showing that it had for many years tried to raise its head above the stems of the heather and had failed. Yet this heath was very extensive and very barren, and, as Mr Darwin remarks, no one would ever have imagined that cattle would have so closely and so effectually searched it for food.

A USEFUL TREE

The following account of a very useful tree is from the interesting "Travels on the Amazon," by Dr Alfred R. Wallace:—

We here saw the different kinds of timber used, both in the log and in boards, and were told their various uses by Mr Leavens. Some are very hard woods resembling oak, and others lighter and less durable. What most interested us, however, were several logs of the masseranduba or milk-tree. On our way through the forest we had seen some trunks much notched by persons who had been extracting the milk. It is one of the noblest trees of the forest, rising with a straight stem to an enormous height. The timber is very hard, fine-grained, and durable, and is valuable for works which are much exposed to the weather. The fruit is eatable and very good, the size of a small apple, and full of a rich and very juicy pulp. But strangest of all is the vegetable milk, which exudes in abundance when the bark is cut; it has the consistence of thick cream, and but for a very slight peculiar taste could scarcely be distinguished from the genuine product of the cow. Mr Leavens ordered a man to tap some logs that had lain nearly a month in the yard. He cut several notches in the bark with an axe, and in an instant the rich sap was running out in great quantities. It was collected in a basin, diluted with water, and brought up at tea-time and at breakfast-time next morning. The peculiar flavour of the milk seemed rather to improve the quality of the tea, and gave it as good a colour as rich cream. In coffee it is equally good.

Mr Leavens informed us that he had made a custard of it, and that, though it had a curious dark colour, it tasted very well.

The milk is also used for glue, and is said to be as durable as that made use of by carpenters. As a specimen of its capabilities in this line, Mr Leavens showed me a violin he had made, the belly-board of which, formed of two pieces, he had glued together with it, applied fresh from the tree without any preparation. It had been done two years; the instrument had been in constant use, and the joint was now perfectly good and sound throughout its whole length. As the milk hardens by exposure to air, it becomes a very tough, slightly elastic substance, much resembling gutta-percha, but not having the property of being softened by hot water, is not likely to become so extensively useful as that article.

SOME NOTABLE OAKS

In the centre of the village, and near the church, is a square piece of ground surrounded by houses, and vulgarly called "The Plestor" [*i.e.* Pleystowe or playing-place]. In the midst of this spot stood in old times a vast oak, with a short squat body, and huge horizontal arms extending almost to the extremity of the area. This venerable tree, surrounded with stone steps and seats above them, was the delight of old and young, and a place of much resort in summer evenings, where the former sat in grave debate, while the latter frolicked and danced before them. Long might it have stood had not the amazing tempest in 1703 overturned it at once, to the infinite regret of the inhabitants and the vicar, who bestowed several pounds in setting it in its place again; but all his care could not avail; the tree sprouted for a time, then withered and died. This oak I mention to show to what a bulk planted oaks also may arrive; and planted this tree must certainly have been, as will appear from what will be said further concerning this area when we enter on the antiquities of Selborne.

On the Blackmoor estate there is a small wood called Losel's, of a few acres, that was lately furnished with a set of oaks of a peculiar growth and great value; they were tall and taper like firs, but standing near together had very small heads, only a little brush without any large limbs. About twenty years ago the bridge at the Toy, near Hampton Court, being much decayed, some trees were wanted for the repairs that were fifty feet long, without bough, and would measure twelve inches diameter at the little end. Twenty such trees did a purveyor find in this little wood, with this advantage, that many of them answered the description at sixty feet. These trees were sold for twenty pounds apiece.

In the centre of this grove there stood an oak, which, though shapely and tall on the whole, bulged out into a large excrescence about the middle of the stem. On this a pair of ravens had fixed their residence for such a series of years that the oak was distinguished by the title of the Raven Tree. Many were the attempts of the neighbouring youths to get at this eyry; the difficulty whetted their inclinations, and each was ambitious of surmounting the arduous task. But when they arrived at the swelling, it jutted out so in their way, and was so far beyond their grasp, that the most daring lads were awed, and acknowledged the undertaking to be too hazardous, so the ravens built on, nest upon nest, in perfect security, till the fatal day arrived in which the wood was to be levelled. It was in the month of February, when these birds usually sit. The saw was applied to the butt, the wedges were inserted into the opening, the woods echoed to the heavy blow of the beetle or mall or mallet, the tree nodded to its fall; but still the dam sat on. At last, when it gave way, the bird was flung from her nest; and though her parental affection deserved a better fate, was whipped down by the twigs, which brought her dead to the ground.—GILBERT WHITE'S "Selborne."

LONDON'S OWN TREE

The plane is the London tree above all others. It flourishes in the heart of the Empire City as does the lime in the near suburbs. Elms are passing away, though, to judge by the size of some of the ruins in Hyde Park and Kensington Gardens, they have had a period of great prosperity. It is a hard blow for those who believe that the air of London has been ameliorated to find these trees succumbing more and more to some new poisonous element that has crept in. Probably their deep-veined leaves are too readily choked by smuts, against the choking action of which the smooth and polished leaves of the plane are evidently an effective guard. Some point to the fungi which deck our elm trees in great profusion as the cause of their decay. They are not the cause, but a symptom, and it is some prior cause that enables them to fasten on the trunks of what the botanist calls their "hosts."

Each snaky twig of the plane now bears a bud of preposterous size, swollen to its utmost and on the point of bursting, so that its children may come forth. They are a goodly family of tiny leaves that will each before summer is ended exhibit a square foot of feeding surface counting both upper and lower sides. And in company with them comes forth a string bearing three balls descending in size from top to bottom. The old seed-balls are still on the tree, so that we can see at a glance what these green babies will become before their day is run. In America the plane is called appropriately button-ball or button-wood, and, less happily, water-beech. Both Eastern and Western planes have been brought to this country, but the Oriental seems to be the more at home. It does not merely persist in London, it thrives. Its polished leaves are one arm of protection against the smuts, its peculiar habit of shedding its bark is another. The winter-fouled outer case is being shed now, and new bark capable of performing its functions is coming to the top. All the year round the green patches can be seen, and, therefore, all the year round the plane is putting into operation this simple plan of keeping the pores open.

The strung buttons of the plane are more in the nature of catkins than anything else. Some are composed of male flowers, others of stigmas. The pollen is collected by a curious arrangement inside the ball, among the stalks of the flowers, whose heads pressed closely together make the periphery weather-tight. Then a dead flower or two fall bodily out, and from the gap the pollen streams forth. Some other ball receives it, and swells to the proportions of the old balls now on the trees from last year. These are now composed of winged seeds, which fly away when the button at length comes to pieces.—G. G. DESMOND in the *Daily News*.

In addition to this descriptive matter will be found many interesting facts, such as "Shoe pegs are small affairs, yet a single factory sends 40,000 bushels of them to Europe yearly, beside what it disposes of in America."

The timber used in the United States of America alone in 1895 has been computed as being sufficient to "load a train 100,000 miles in length, or long enough to reach four times around the globe. Enough to load 480,000 ships of 1000 tons each." Also "taking the yield of an average spruce fir, from which wood pulp is made, as about 500 lbs. of paper, nine works of fiction were recently responsible for using up no less than four thousand trees."

. . . .

For further references see end of next chapter.

CHAPTER IX

TREES AND TIMBER (*Continued*)—THE DIFFERENT VARIETIES—MATTER FOR OBSERVATION LESSONS

CONIFERS AND BROAD-LEAF TREES

FOR the timber user the most convenient classification of trees is into (*a*) Conifers or Narrow-leaf trees, (*b*) Broad-leaf treees.

The pupils may be asked to bring leaves and seeds of both varieties, if they can be procured, and instructed to note the general appearance of the trees from which they obtain them. Failing these, blackboard sketches, or diagrams, or pressed leaves must serve. Draw up a list of the specimens under the two headings :—

Broad-leaf trees.—Oak, ash, elm, beech, birch, lime, sycamore, etc.

Narrow-leaf trees, or Conifers.—Various pines and firs, larch, cedar, yew, and cypress.

Question as to the appearance of the two types of trees, bringing out the fact that most of the broad-leaf trees have bushy heads and short, irregular trunks; whereas, as a rule, the conifers have straight, tapering, stems and pyramidical outline.

In a succeeding lesson further differences and contrasts may be pointed out. Find out what the pupils know as to the fruit or seeds of the two varieties, which trees are evergreen, whether the timber is hard or soft, resinous or non-resinous. Make a blackboard summary somewhat as follows :—

Broad-leaf Trees	*Conifers.*
1. *Seeds.*—Various in form, as acorn, winged seeds of sycamore, beechnut, plane tree "buttons," etc.	1. The seeds are in the cones.
2. The leaves fall each year.	2. Evergreen (except larch).
3. Wood not resinous.	3. Resinous (except yew.)
4. Wood is hard as a rule.	4. Generally soft.

A chat about the flowers and seeds of trees may next be given. Call attention to the fertilisation of flowers by bees. Pines, firs, poplars, birches, etc., are independent of the insects for the purpose as they are wind-fertilised. Wind-fertilised flowers usually develop before the leaves are formed so that the pollen has a better chance to reach its proper destination. This yellow pollen dust is produced in great abundance. Whenever there is a probability of waste, as in this case, Nature takes good care that large quantities are furnished to allow for the wastage. Showers of pine pollen are sometimes carried quite a long way. At one time these "showers of sulphur" were a source of amazement and alarm to superstitious people. The wind has carried the pollen from remote forests to the streets of some town, giving the pools formed by the rain a yellow hue; this has been taken by the inhabitants to be a veritable fall of sulphur, and a foretaste of something worse to follow.

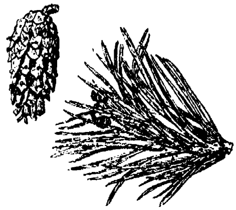
The cones on a fir tree are at first upright; after being fertilised by the pollen in May or June, they droop downward, but remain on the tree till the following spring or longer, when the wind shakes out the seeds or brings down the cone. If a cone be examined, it will be found to consist of numerous overlapping hard, brown scales. There may be 150 or more scales on one cone, each hiding two seeds on its upper side, so that a cone may contain from 300 to 350 seeds. Each seed is attached to a thin wing, almost like an insect's.

What purpose does the wing serve ?

Are all trees dependent on the wind for dispersing their seeds ?

NORTHERN PINE (*Pinus Sylvestris*).

Prepare the following objects: (1) A portion of the trunk of the Northern Pine, showing the bark and horizontal and vertical sections. (2) A pine cone. (3) If a tree, or a small branch of the tree, is not available provide either a photograph or a diagram. (4) To these may be added some specimens of the by-products of the tree, such as turpentine, resin, etc.


Leaves and partly opened Cone of the Northern Pine

Have these conveniently arranged for the inspection of the class. A good plan is to have them on view beforehand and allow the boys to examine them two or three at a time and make their own observations.

Summarise these observations of the children on the blackboard.

1. *General appearance.*—Tall; clear of branches for some distance above ground; open foliage.

2. *Bark.*—Rough and reddish, deeply furrowed or flaky.

3. *Leaves.*—Long green needles, a pair in each tuft.

4. *Cones.*—Conical in shape; contain numerous winged seeds. (It takes about 75,000 seeds to make a pound.)

5. *Wood.*—Yellowish white in colour; resinous; annual rings very distinct.

It thrives further north than other pines, hence its name Northern Pine. The leaves are thick-walled and protected by their varnish-like surface from the winter frost. They are evergreen, and so the leaves get the benefit of what sunlight is available throughout the year. Call attention to the advantage the narrow leaves have in situations exposed to violent winds.

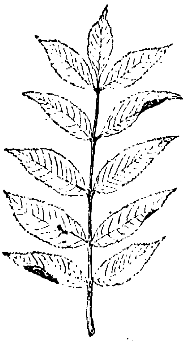
The tree is common in Scotland and is often called the Scotch Pine. It grows throughout the greater part of Europe and Northern Asia. The countries round the Baltic are the main sources of our supply.

The timber stands exposure to the weather and is largely used for roofing, doors, windows, beams, and general building purposes. It is strong and durable. The wood is generally known as yellow deal, but in some parts of the country as red deal. The sapwood has a bluish tint. Tar, pitch, turpentine, and resin are also products of this tree.

THE ASH (*Fraxinus Excelsior*).

> "Amid the brook
> Grey as the stone to which it clung half root,
> Half trunk, the young ash rises from the rock:
> And there the parent lifts its lofty head,
> And spreads its graceful boughs; the passing wind
> With twinkling motion lifts the silent leaves
> And shakes its rattling tufts."—SOUTHEY.

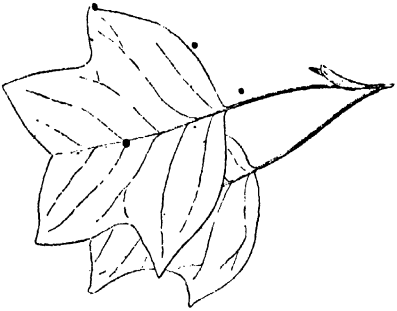
The natural beauty of the Ash long ago earned it the title of "Sylvan Venus." The tree is especially noticeable for elegance of form and the light and pleasing foliage of its graceful, waving branches. Till quite recently children suffering from certain afflictions were passed twice through a cleft ash in order to effect a cure! The "Shrew-Ash" was a tree in which an innocent little "shrew-mouse" was imprisoned by boring a hole and afterward plugging it up with the live animal inside. The tree was henceforth invested with the miraculous power of curing cramp, so that a touch of its magic leaves would afford relief!


LEAF of the ASH.

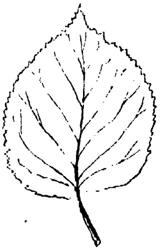
The wood of the ash tree is light brown or greyish white in colour. Although hard, tough, and elastic, the wood is not particularly difficult to work. It can be bent to almost any curve when steamed at a high temperature, and retains the shape when cool. The sapwood can scarcely be distinguished from the heartwood, and is just as serviceable as the rest of the wood.

On account of its peculiar properties we find an old author recommends that a "proportional number of ash trees should be planted in every farm. For it is one of the principal materials in making ploughs, harrows, wagons, carts, and various other implements for rustic use. Also dairy utensils are mostly made of ash, and its loppings make good fuel; it has the quality of burning fresh as well as dry, and also with little smoke. Its ashes afford good potash and the bark is used in tanning calf-skin. The leaves are eaten by cattle." Later authorities state that cows fed on ash leaves fail to produce good butter.

At the present day it is largely used by the wheelwright and also by the cabinetmaker. It is used for parts of tools, such as hammer shafts and chisel handles; for coach building, wheels, and bent shafts; for oars, and tennis bats; and gymnastic apparatus on account of its elasticity. The world's supply is obtained from Great Britain, Asia, and America. To prevent deep shakes from appearing in ash it should be cut in planks soon after felling, and stacked with small fillets between them to prevent warping. The wood is durable if kept dry, but soon rots if alternately wet and dry.



Basswood (Liriodendron Tulipifera).



Basswood (Tilia Americana).

Basswood (*Tilia Americana* and *Liriodendron Tulipifera*).

> "The cross bars were ash, from the straightest trees,
> The panels of white-wood, that cuts like cheese,
> But lasts like iron for things like these."
>
> O. W. Holmes, "One-hoss Shay."

The wood sold under the name of Basswood comes from at least two species of tree. Even in the United

States of America, where these trees grow, there is no uniformity of nomenclature. The wood of the *Tilia Americana*, besides being known in America as basswood, is also called American linden, limetree, white lind, whitewood, wickup, and yellow basswood. It is a yellowish brown colour with slightly greenish tinge, and in texture something like the ordinary lime tree of Europe. The sapwood is scarcely distinguishable, and the wood is not liable to shrink much. The wood of this tree is harder to work than that of the *Liriodendron tulipifera*. The inner layers of bark are made into matting.

In America the wood of this last tree receives, among many others, the following names: Tulip tree, yellow poplar, white poplar, blue poplar, hickory poplar, white wood, canoe-wood, old-wife's-shirt-tree, and basswood. The colour is from lemon-yellow to a greenish-yellow, the wood being easy to work and very suitable for manual training purposes. The sapwood is white and rather abundant. The wood is light in weight, not very durable, and shrinks a great deal. The leaves are of a peculiar shape, and not often seen in England as few trees have been planted here.

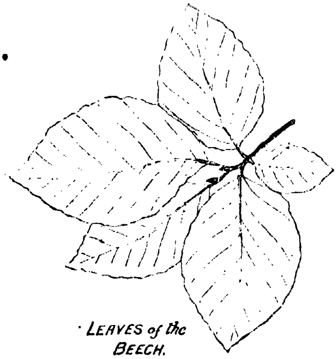
Basswood is used for common furniture and carvings, domestic utensils and electrical fittings, broad panels, and fancy articles. It takes stain very well. Our supply is obtained from Canada and Eastern States of America.

THE BEECH (*Fagus Sylvatica*).

> " There is a man haunts the forest, that abuses our young trees
> With carving Rosalind on their barks."—SHAKESPEARE.

The stateliness of the beech, together with the shelter it affords to young trees, has earned for it the title of

"Mother of Forests." It is common in our parks and woodlands, a noticeable variety being the Copper beech with its beautiful rich red leaves. The leaves of this tree contain an oil which has been expressed and used in some countries instead of butter, while the three-cornered nuts that grow in a bristly capsule have in times past served as food for pigs and poultry. Deer, squirrels and dormice also feed on these nuts. The bark of the tree is smooth, "inviting the wandering lover to carve thereon the name he adores," as an old writer says. The wood is hard, close grained, with a very distinct medullary ray, the colour being a light brown. It quickly decays when exposed to alternations of wet and dry. It is very liable to be attacked by worms, which often leave only a very small portion of solid material undestroyed.



· LEAVES of the BEECH.

Stocks and handles of tools, planes, etc., are made from this wood. It is also used for furniture—especially chairmaking, cooper's work, and piles, and for bentwood chairs. It makes good charcoal and the bark has been employed instead of oak bark in tanning leather. The tree grows in Great Britain, Europe, Australia, and America. Many localities in England are noted for beech trees which have attained a notable size, thus we have Burnham Beeches, and Knockholt Beeches in Kent.

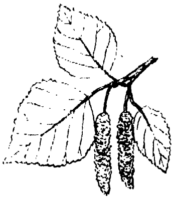
THE BIRCH (*Betula Alba*).

"The silver birch is a dainty lady,
She wears a satin gown."—"Child's Song in Spring."

No one who has once had this tree pointed out to him can fail to remember it. The silvery bark, the comparative smallness of its leaves, and its slender form are all alike remarkable. Coleridge wrote of this tree:—

"Most beautiful
Of forest trees—the Lady of the Woods."

The wood of the birch tree is straight in grain, hard, tough, and able to stand wear and tear. It is used for cabinet-making and various kinds of furniture, work benches, and is an excellent wood for the wood-turner. The colour is light or reddish brown. The bark is said to be almost imperishable; houses are covered with it in some parts of the world, and utensils and ropes are made of it. American Indians use the bark for making canoes, tents, troughs, and buckets.



LEAVES and CATKINS of the BIRCH.

"In his birch-canoe exulting
All alone went Hiawatha."

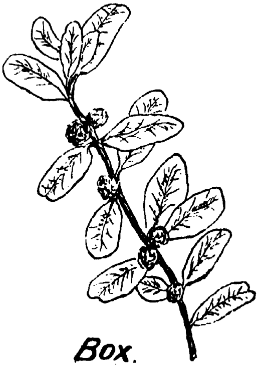
An old Scotch professor gives another use for birch when he writes that "schoolmasters and parents do terrify their children with rods made of birch." As far back as 600 B.C. thin layers of the bark of the birch were used for writing upon.

Birch is grown in Europe and in America. The Russian variety is sometimes called Russian maple, and is the wood mostly used in making the thirty millions of wooden spoons that are made annually in that country.

THE BOX (*Buxus Sempervirens*).

> " Smooth-grained, and proper for the turner's trade,
> Which curious hands may carve, and steel with ease invade."
>
> DRYDEN.

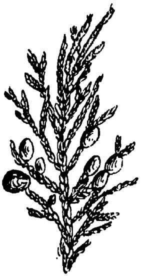
Owing to the very slow growth of the Box tree it is most often met with as edging to garden beds. When full grown it attains a height of from 15 to 20 feet, with a girth of about 18 inches. At Box Hill, near Dorking in Surrey, are to be found some famous box trees. Sufficient trees are recorded to have been felled in 1815 at this famous place to realise £10,000. The English box is extremely hard, and so heavy that it sinks in water. At one time large quantities were used in making wood blocks for book illustrations, owing to its close, even grain. It is rarely used for this purpose now, as zinc and copper have taken its place.



Box is used for rules, small turnery, carvings, draughts and chessmen, and parts of mathematical instruments, also for handles and other parts of tools having to stand considerable wear, such as screws of gauges, etc.

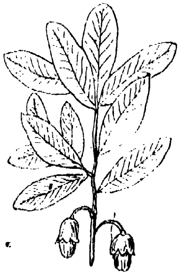
A much softer variety known as Turkey box is imported into this country, and can be had in very much larger sizes than English box. Turkey box is grown both in Europe and Asia. The colour of the wood is a bright yellow and the grain is very indistinct.

CEDAR (*Juniperus Virginiana*).



RED CEDAR.

There are many "cedars," this one, known as the Virginian Cedar, growing in the United States and West Indies. The tree is conical in shape, with horizontal branches bearing small leaves and bright blue berries. The wood is a brownish red, with white sapwood, and has a fine grain with annual rings faintly marked. Some boards are not unlike mahogany, to which tree the cedar is allied, but can be distinguished from it by the length of the short hair-like markings formed by the section of the numerous vessels that occur in this wood. It is easy to work, and when not spongy is suitable for manual training purposes. Sometimes a rather strong odour is perceptible; this repels insects and makes the wood suitable for making wardrobes and other pieces of furniture in which clothes have to be stored. It has no great strength; is very durable, and shrinks and warps but little. Among other varieties of cedar are the renowned Cedar of Lebanon, Pencil Cedars, besides several English varieties.



EBONY

EBONY (*Diospyros*).

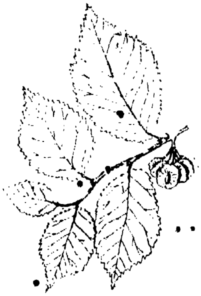
The wood of the Ebony tree is remarkable for its great density and dark colour; it sinks in water. Though in the main black, it has lighter markings, while the sap-wood is a very light grey. It grows in India and Ceylon. The demand is not great owing to the difficulty of working and its small size. The wood is very liable to split and is therefore cut into the sizes required as soon as possible. It is used for cabinet work, parts of electrical fittings, and tool handles.

THE ELM (*Ulmus*).

> " Enormous elm-tree boles did stoop and lean
> Upon the dusky brushwood underneath,
> Their broad curved branches fledged with clearest green
> New from its silken sheath."—TENNYSON.

> " Our elm-tree's ruddy-hearted blossom-flake is fluttering down."
> TENNYSON.

The elm is to be commonly met with in country walks and in our natural parks. The tree rises to a good height, and is of rugged appearance, the bole being covered with a rough bark. The leaves, which are small, are covered on the underside with small hairs that have the power of stinging slightly, like those of the nettle. Though elms have been known to live over 500 years, yet they are very liable to decay and large branches often give way suddenly in a wind. The wood of this tree is open grained but somewhat twisted, the colour being a reddish brown. There are four species growing in Great Britain, of which the common or small leaved elm (*Ulmus Campestris*) is by far the most frequent. This variety is said to have been introduced by the Romans. In addition to the species growing in the United Kingdom other species are grown in Europe and America. The wood is durable when kept dry or under



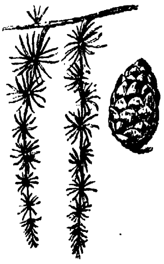
LEAVES and FRUIT of the ELM

water, but will not stand alternations of these states. As elm is likely to prove faulty if left to the weather, only freshly cut wood should be used, in this state the working of the wood is easier. When a stock is kept the wood may be stored under water to preserve the good working qualities of fresh elm. It is used for piles, plankings in wet foundations, pulley blocks, naves of wheels, coffins, pump boxes, wooden springs, and whenever a wood is required to withstand sudden shocks, gun carriages for example. Furniture is sometimes made from it on account of its colour and natural beauty of grain. On account of its toughness the seats of wooden chairs are made of it. Sapwood of elm is as durable as the heartwood and lighter in colour. Like ash, the springwood is open in texture, thus clearly distinguishing the annual rings.

LARCH (*Larix Europæa*).

> "I have passed o'er the hills of the strong north,
> And the larch hath hung all her tassels forth."
>
> MRS HEMANS.

The Larch is grown in England but the wood does not attain its best qualities in this country. It is also found in Switzerland, Italy, Germany, Russia, and America, the Russian timber being considered the best. The tree has a straight tapering trunk growing up to 100 ft. in height. The larches alone among the coniferous trees shed their leaves each winter. The wood is of a dark yellow colour with annual rings strongly marked. It is useful for rough outdoor work, posts, railings, railway sleepers, etc. It wears well, is very



LEAVES and CONE of LARCH.

durable, but splits and warps a good deal in seasoning and so is unsuitable for fine work.

MAHOGANY (*Swientenia Mahogani*).

This wood is known by two varieties; Spanish and Honduras Mahogany.

Spanish Mahogany is grown in Cuba, Jamaica, and St Domingo. The tree is a large one taking about 200 years to mature. The wood is of a rich dark red colour with chalk-like markings owing to the presence of a white flinty substance in its pores which blunts the plane. The Spanish variety is heavier than that grown in Honduras but has a better figure, which gives it a more handsome appearance. It is very durable if kept dry, warps but little and holds glue very well. Owing to its price and the extra cost of working, the Spanish variety is only used for the more expensive work. It is used for bank, shop, and ship fittings, and for cabinet-making.

MAHOGANY.

Honduras Mahogany, or Baywood, grown in British Honduras, is obtained from a large tree growing over 100 ft. high, bare of branches up to 60 ft., and then forming a massive head with shining green leaves and saffron flowers. The wood is lighter in colour than the Spanish variety and not so heavy in weight. It is softer and easier to work, and used for making small patterns as it warps and shrinks very little. In the best class cabinet work this wood is used as a base for expensive veneers. It is durable when kept dry. Planks of this wood can be had up to 7 ft. in width, making it suitable for counter-tops, desks, table tops, etc.

THE OAK (*Quercus*).

> "A little of thy steadfastness,
> Rounded with leafy gracefulness,
> Old oak, give me,
> That the world's blasts may round me blow,
> And I yield gently to and fro,
> While my stout-hearted trunk below
> And firm-set roots unshaken be."—LOWELL.

No tree is so typically English as the oak. Everyone is familiar with the appearance of its short, stout trunk, its massive, tortuous branches, and the sinuous outline of its leaves. From the earliest times it has played an important part in the history and progress of our country. At the time of the Norman Conquest, oak was chiefly valuable for the pannage of swine that its acorns—along with the nuts of the beech—provided in such abundance. The old Domesday survey gives the extent of the forests as woods of so many swine according to the number they would fatten. The survey seems to have been thoroughly done, for in some cases woods are mentioned "of one hog." Readers of "Ivanhoe" will remember Gurth the swineherd. Besides forming food for swine the acorn was a toothsome relish to the king's deer sheltered in the forests as animals of the chase. In times of famine people were glad of the acorn as food for themselves. Indeed, during the Peninsular War the troops often fed with hungry relish on the acorns of the Spanish and Portuguese woods. Epping Forest yields quite a harvest of acorns, and it is no uncommon sight to see men and boys with sacks gathering the fallen crop in the Chingford woods to sell as food for pigs.

But it was as a shipbuilding material that England owed so much to the oak. From the days of King Alfred down to Drake, Hawkins, and Raleigh, right on to Nelson's time, oak is closely associated with England's naval prowess. Such terms as "hearts of oak" and "the wooden walls of old England" in song and story tell of our indebtedness to the stout oak in this respect. The twisted nature of the oak branches gave natural "crooks" or "knee timber" to the shipbuilder for making the "knees" or ribs for the ship's framework.

OAK LEAVES.

Oak is now used for cabinet-making and furniture, where its medullary rays give the beautiful figure or "silver grain" so characteristic of this timber; for carved work and the finest class of joinery, staves of casks, spokes and axle pieces of wheels, rungs of ladders, and split for oak palings. For any purpose requiring strength, toughness, and durability no better timber could be used. Iron nails or hinges are not suitable for oak timber as the tannic acid it contains corrodes iron, turning it in fact into ink. Such inky stains may often be seen on oak fences and gate-posts.

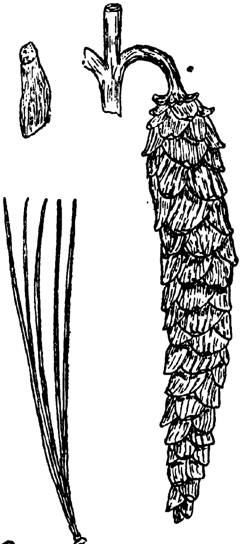
There are said to be more than 300 varieties of oak growing in the belt of land including Europe, China, Japan, and other parts of Asia, and North America. The wood varies considerably in colour and density according to the soil in which it grows. English oak is greyish or yellowish brown, turning darker with age. It is difficult to work owing to its twisted fibres as one may readily infer from the crooked limbs of the growing tree. The American timber is much straighter in grain, easier to work, and of a reddish tinge.

The character of the growing tree is well brought out in the following eloquent and suggestive passage from the genial "Autocrat of the Breakfast Table":—

"There is a mother-idea in each particular kind of tree, which, if well marked, is probably embodied in the poetry of every language. Take the oak, for instance, and we find it always standing as a type of strength and endurance. I wonder if you ever thought of the single mark of supremacy which distinguishes this tree from all our other forest trees? All the rest of them shirk the work of resisting gravity; the oak alone defies it. It chooses the horizontal direction for its limbs, so that their whole weight may tell,—and then stretches them out 50 or 60 feet, so that the strain may be mighty enough to be worth resisting. You will find that, in passing from the extreme downward droop of the branches of the weeping willow to the extreme upward inclination of those of the poplar, they sweep nearly half a circle. At ninety degrees the oak stops short; to slant upward another degree would mark infirmity of purpose; to bend downwards, weakness of organisation."

Where oak is grown solely for its timber, this horizontal spreading of the branches is not desirable, as it results in a short stem. By planting them closely together and thinning out as the trees increase in size; or better still by interspersing beeches with the oaks, giving the latter some years' start, long straight stems are produced yielding the maximum amount of timber. Larch and silver fir are sometimes used also for underplanting oak woods. Such woods require attention on the forester's part to guard against overcrowding, the aim being to set up competition for the necessary sunlight and thus force the trees to push upwards, the lower branches being killed off and straight, clean boles produced.

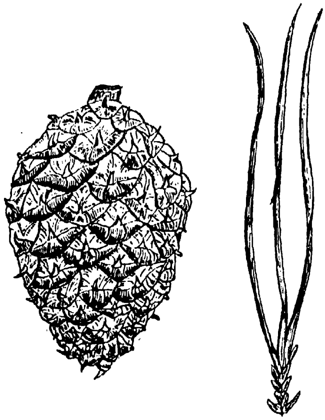
Gilbert White mentions striking examples of both these types of oak. See page 122.



CONE, SEED, and LEAF BUNDLE of WEYMOUTH P.

American Yellow Pine or Weymouth Pine (*Pinus Strobus*).

This is the largest of the conifers indigenous to the eastern part of the United States of America. The tree is sometimes grown in Great Britain. The leaves grow in clusters of five, and the bark is light in colour, hence the name of white pine by which it is known in America. The tree sometimes reaches the age of 250 years and attains a height of over 150 feet with a diameter of 3 to 5 feet. The wood is soft, light, straight grained, easily worked and does not warp. It can be recognised by the short hair-like marks that are often found in the grain. Compared with northern pine, the wood is less resinous, freer from knots, annual rings less distinct, and it is not so durable. It is a valuable wood for pattern-making and cabinet-making, as it does not warp and will take glue well. It is sometimes used for cupboards and fittings, but is not sufficiently strong or durable in our climate for general constructional work. It is used in America for making matches, as it splits easily and is free from knots. It is far more suitable for manual training than the yellow deal which is so commonly used.



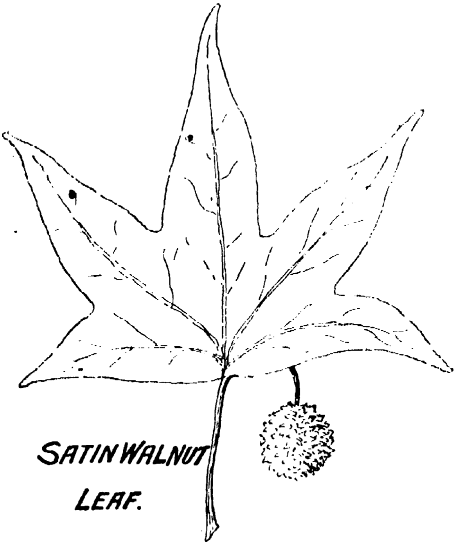
CONE and LEAF BUNDLE of PITCH PINE.

PITCH PINE (*Pinus Australis and Rigida*).

The name pitch pine is given to the timber of several pine trees grown in America. The *P. Australis* is said to yield the best timber. At least two varieties are known as long-leaved pine, and produce a large quantity of turpentine. The tree grows to a height of from 60 to 100 feet. The wood is one of the heaviest of the coniferous woods; the annual rings are very distinct; it abounds in resin, and is liable to cup shake. The bright orange-yellow colour and strongly marked grain make it suitable for ornamental joinery, but it is often very difficult to work on account of the resin clogging the tools. When the tree has been "bled" to extract the turpentine, the wood is rendered inferior in quality as regards both strength and durability. Uses: shop fittings, structural work generally, church fittings, school desks, floors, and other purposes demanding great resistance to wear.

SATIN WALNUT (*Liquidambar Styraciflua*).

The satin walnut is not, as its name would imply, a walnut tree at all. This tree, which is indigenous to the United States of America and Mexico, is often 80 to 90 feet high, with a tapering stem and small branches. In America it is also known as Red-gum, Alligator-wood, and Bilsted. The wood has a handsome appearance, due to peculiar dark markings which enrich its light brown surface. It is fairly easy to work, leaving a lustrous surface from the plane. It has a white sapwood. This

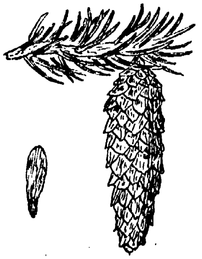


wood shrinks and twists considerably, and unless properly prepared, by cutting the boards from the log radially so as to obtain boards that are less liable to warp, is somewhat unsatisfactory to make up. Its even texture, however, makes it suitable for carving and manual training work. It is also used very considerably in making bedroom furniture on account of the light colour of the wood.

The SPRUCE FIR (*Picea excelsa*).

> "The fir trees, gathering closer in the shadows,
> Listened in every spray."—BRET HARTE.

The spruce fir grows in Great Britain and reaches a height of about 130 to 150 feet. The pupils will best know this tree in its diminutive form as a Christmas tree. It is pyramidal in form, the main stem rising vertically and tapering gradually, with numerous slender branches growing out in a slightly downward direction. The tree, in common with other firs and pines, is an evergreen; the leaves remain on for three or four years, but are being constantly renewed, so that the tree is always green. The cones, which are the female flowers, grow at the end of last year's twigs and attain a length of about 5 inches, hanging downwards. The leaves grow singly and not in small bunches as in the pines. The wood is of varying quality, and is known as White Deal as well as Spruce.



SPRUCE FIR CONE, LEAVES, and SEED.

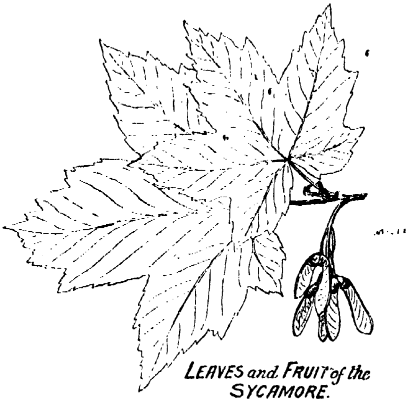
The plane leaves a silky surface on the best quality wood. A peculiar characteristic is the small knots, often found in large numbers. These are very hard and in some Russian deals exist as "dead" or loose knots surrounded with bark. The wood is elastic, tough, and except for the knots easy to work. It is very durable and on account of its white colour valued for dresser and table tops. It is also used for common joiners' work, floor boards, etc. On account of its cheapness the roughest is used for making packing cases and crates, while the cleaner wood is largely used in making wood pulp for the manufacture of paper. The tree grows in Norway, Sweden, Russia, and the North of Europe generally. Burgundy pitch is obtained from its resin. Young trees, closely planted so as to cause straight growth, are used for scaffold poles. From similar poles ladders are made.

SYCAMORE (*Acer Pseudo-platanus*).

> "And thou, with all thy breadth and height
> Of foliage, towering sycamore."—TENNYSON.

This tree grows quickly and may attain a height of 60 to 80 feet in fifty or sixty years. It belongs to the family of maples, and should not be confounded with the plane tree that at first sight it somewhat resembles. Both these trees are to be found in our streets, and a comparison of their leaves is instructive. The seeds of these trees are also quite different. The sycamore in common with other maples contains a sugary sap which Scotch children are said to obtain by making an incision in the bark, through which the sweet sap flows freely. The wood is white in colour, the centre of the tree turning brown with age; close grained, with no distinct markings. It gives a fine glossy surface when planed, is tough to work and fairly heavy. It grows in Great

Britain, Germany, and America. The wood is used for turnery, cutting boards, mangle rollers, and musical instruments, and is durable if kept dry. With the exception of holly it is the whitest wood we have and is

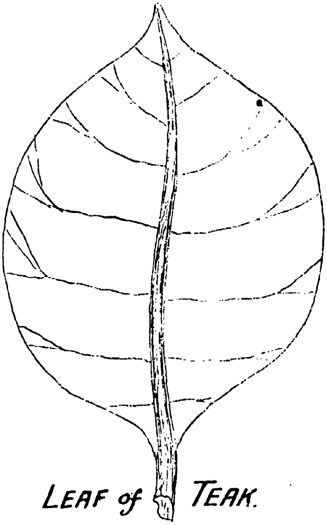


LEAVES and FRUIT of the SYCAMORE.

therefore used for inlaying. It takes a dye well and thin wood is often treated in this way for inlaying work-boxes, etc. Sometimes the darker sycamore closely resembles beech, but may be distinguished by its fine medullary ray. On the end grain these take up half the surface, whereas in beech they occupy one-sixth.

TEAK (*Tectona Grandis*).

The teak tree is of rapid growth and is found in urmah, Java, and Ceylon. It reaches to a height of to 150 feet with a diameter of 2 to 3 feet. The wood when freshly cut is of a green colour, but changes on exposure to a dark brown. The wood is generally straight grained and contains an aromatic resinous oil which hardens in the pores and makes it difficult to work. This oil gives the wood an unpleasant smell but prevents the attack of insects; it also preserves ironwork and is therefore used as a backing for armour plating of ironclads. The wood is lighter than oak, but is stronger and more durable under water. It is used for ship's fittings, railway carriages, laboratory fittings, gun carriages, shop fittings, doorsteps, window frames, and in fire-resisting construction for stairs and floors.

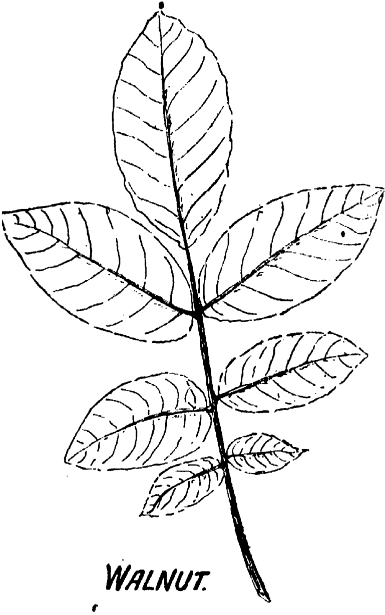


LEAF of TEAK.

WALNUT (*Juglans*).

"Her timber is for various uses good,
The carver she supplies with useful wood.
She makes the painter's fading colours last,
A table she affords us and repast."—COWLEY.

The walnut tree which grows in England is the *Juglans Regia*, and was introduced about the middle of the sixteenth century. The tree grows to 60 feet high and has wide spreading branches, which provide excellent shade for cattle. The wood of the walnut tree is a dark brown colour, having a handsome appearance, due to its peculiar markings, which makes it a suitable wood for cabinet - making and shop fittings. The American variety (*Juglans nigra*) is somewhat similar in appearance but of a dark purplish brown; is straighter in the grain and easier to work than the English variety. It is the best kind for manual training. Most of the walnut imported into this country comes from the Black Sea. The best variety is that known as Italian walnut. This wood keeps its shape when well seasoned, and is used for rifle stocks, veneers, superior joinery and cabinet work. Burr walnut is used for veneering pianos, table tops, etc.

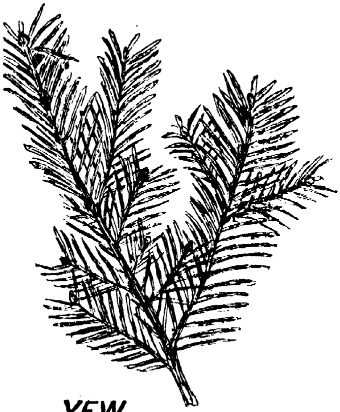


YEW (*Taxus Baccata*).

"This solitary tree! a living thing
Produced too slowly ever to decay,
Of form and aspect too magnificent
To be destroyed."—WORDSWORTH.

"The eugh, obedient to the bender's will."—SPENCER.

The yew is a needle-leafed tree, but does not bear cones. The fruit is a bright red berry, which stands out conspicuously from the dark green foliage which always clothes the tree. It yields a reddish brown timber useful for veneering and inlays. In former times it provided English archers with strong bows that proved dangerous on many a well fought field. Roger Ascham in "Toxophilus" says of yew: "If you come into a shoppe and find a bow that is small, longe, heavye, strong, lyinge streighte, not windynge, nor marred with knottes, gaule, wyndshake, wen, freet or pinch, bye that bowe on my warrant."



YEW.

References—

"Familiar Trees," by G. S. Boulger (Cassell & Co., 2 vols., 6s. net each); "Timber and Timber Trees," by Laslett (Macmillan, 7s. 6d.); "Timbers and How to Know Them," by Dr R. Hartig (2s.); "The Forest Trees of Britain," by Rev. C. A. Johns

(Society for Promoting Christian Knowledge); "The Oak," by H. Marshall Ward (Paul, Trench & Co.); "Wayside and Woodland Trees," by Edward Step (Warne & Co., 4s. 6d.); "Soft Woods and Colonial Timbers" and "Hard Woods," by Percy A. Wells (Marshall & Co., each 6d. net.); "Timber and Some of its Diseases," by H. Marshall Ward (Macmillan, 6s.); "Our Trees and how to Know Them" (Gowans, 6d.); "Primer of Forestry" (2 Parts), and other admirable bulletins issued by the Department of Agriculture of the United States of America; "Timber" (Cassell, 6d.); "Forestry," by A. Schwappach (Dent & Co., 1s.).

CHAPTER X

TOOLS, MATERIALS, ETC.

MATTER FOR OBSERVATION LESSONS

On Angles

LESSON I.—Give every boy a piece of paper and let him fold it so as to produce the crease AB (Fig. 1). Fold this crease upon itself so that A falls upon B. Two lines at right angles to each other are thus made. Question the class so that this fact will be brought out. Also elicit what an angle is.

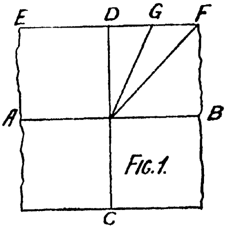


FIG. 1

Are all angles right angles?

If not, what are they? "*Obtuse and Acute.*" Allow one or two boys to sketch an acute angle on the blackboard.

If it were required to cut a board to one of these angles how could it be marked out correctly? Various and often ingenious suggestions will be made for doing this.

It is required to telegraph this angle, how may it be done? *Send the size.*

How can it be measured? Can we compare it with our right angles on the paper? Let the pupils tell you what part of a right angle it appears to them to be.

If we divide our right angle into equal parts could we not measure more accurately with our paper? *Yes.*

Can you tell me how to get half a right angle? Suggestions are received from the pupils for folding the paper, bisecting the angle with compasses, etc. Having obtained the angle of 45° tell the class that a right angle is divided into 90 parts called degrees. Ask for suggestions for doing this.

Can we measure equal distances along the edge EF, join to the centre and so obtain equal angles? Let the class try for themselves by taking large equal divisions, when the resultant angles will be obviously different as at DGF (Fig. 1). The need for the circle for purposes of division is now seen.

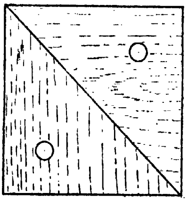


FIG. 2

For further illustration the angles between the hands of a clock can be used. What is the angle between the two hands at 2 o'clock, 3 o'clock, etc.?

If a watch is used instead of a clock what difference will it make?

A jointed rule, or the legs of the compasses can be used in explaining what an angle is.

LESSON 2.—*The Set Squares.*

(*a*) Place two 45° set squares, as shown in Fig. 2, and ask what is formed. *A square.*

How many degrees are there in each angle of the square?

When the square is cut across the corners, what are the angles in each part? 90°, 45°, 45°.

(*b*) Place two 60° set squares as in Fig. 3. What is formed? *An oblong.*

What is each angle? Show by placing two 60° squares as in Fig. 4, and covering angle EFG by CAB (Fig. 3) that the angle CAB is twice the angle CAD. Therefore CAB is 60° and angle CAD is 30°. Place six 60° angles together and show that they make up 360°.

What figure is formed when two 60° squares are placed as in Fig. 4. *An equilateral triangle.*

What relation has a 60° set square to the equilateral triangle? *It is half an equilateral triangle.*

Name the sizes of the three angles—90°, 60°, 30°.

If the longest edge of this set square is 8 inches, what is the length of the shortest edge? 4 *inches.*

Why? What is a right angled triangle?

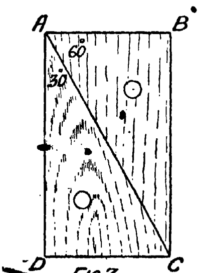


FIG. 3.

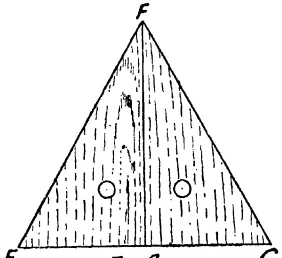


FIG. 4.

LESSON 3.—*To show that the three angles of any triangle together contain* 180°.

(*a*) Add together the angles of the set squares and write each total on the board without previously making known the fact that is to be taught in this lesson. Also add together and write down total of the three angles of the equilateral triangle (Fig. 4).

Ask the class if they notice anything about the three totals. *Yes, they are all equal.*

Give each boy a piece of paper and let him cut a triangle from it. How can the three angles of this paper triangle be added together? Tear off the corners of the triangle as in Fig. 5, after lettering the angles. Place them together and test with a straight edge (Fig. 5).

How many degrees in the three angles, B, A, and C?

Another method of demonstrating this fact is to fold the paper triangles as in Fig. 6.

If one angle of a triangle is known to be 80°, another to be 70°, what is the remaining angle ? *One of* 30°.

Lesson 4.—*To show the number of degrees in the added angles of figures of more than three sides.*

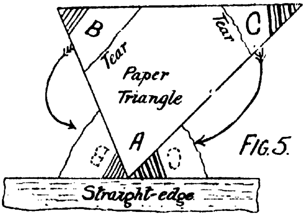


FIG. 5.

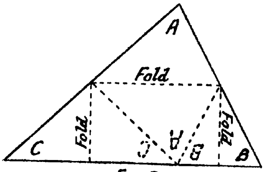


FIG. 6.

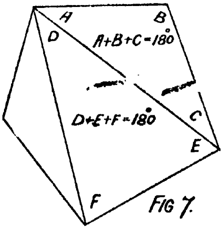


FIG 7.

(*a*) Draw any four-sided figure and show that from one of its corners it may be divided into two triangles.

How many degrees in the added angles of a triangle ? 180.

How many degrees in the added angles of the figure ? 360.

(*b*) Draw a five-sided figure and divide as in Fig. 7. How many degrees in the added angles of the whole figure ? 180° x 3.

Inference—The angles of every five-sided figure contain together 540°.

(*c*) Repeat with six and eight sides.

(*d*) Write on the board the results obtained thus :—

In a 4 sided-figure the total number of degrees = 180 × 2
" 5 " " " " 180 × 3
" 6 " " " " 180 × 4
" 8 " " " " 180 × 6

Ask the class to see if any relation holds between the number of sides and the number by which 180 has to be multiplied to obtain the required total in each case. If this does not draw the answer sought for, repeat the question by asking how many triangles a four-sided igure can be divided into. *Two.*

How many is this less than the number of sides ? *Two.* And so on with the other figures. The number of triangles that can be made in any figure having straight sides, by drawing lines from one corner to the remaining corners, is always equal to the number of its sides less two.

(*e*) If a four-sided figure has angles of 105°, 100°, 80°, what is the remaining angle ? 75°.

LESSON 5.—*To find the angles of regular figures.*

(*a*) Educe that a regular figure has all its sides equal and therefore all its angles equal.

(*b*) Ask the names of the regular figures :—Equilateral triangle, square, pentagon, hexagon, etc.

The added angles of figures of
3 sides contain 180° ∴ each angle $= \frac{180}{3} = 60°$
4 " 180° × 2 ∴ " $= \frac{360}{4} = 90°$
5 " 180° × 3 ∴ " $= \frac{540}{5} = 108°$
and so on.

Show this is true in the case of a hexagon by drawing this figure in a circle and joining its angles to the centre, thus giving six equilateral triangles. The angle of the equilateral triangle is 60°. Two such angles make one of the hexagon.

In the case of the octagon, inscribe that figure in a square and show that the corners cut off the square are right angled triangles having the other angles each 45°. This subtracted from 180° leaves 135°.

TESTING STRAIGHT-EDGES AND SQUARES

1. STRAIGHT-EDGE.—Draw a line with the straight-edge in the position AB (Fig. 8). Reverse the straight-edge by turning it over without reversing the position of the ends as in Fig. 8. The edge is straight if it fits the line drawn when in its first position.

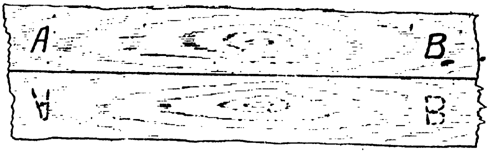


FIG. 8.—Test for Straight-edge.

2. SET SQUARES.—(*a*) *To test the right angle.* Place the set square against a straight edge, as in the first position (Fig. 9), and draw a line AB. Keep the straight-edge fixed and reverse the set square into the second position. If the upright edge coincides with line AB the angle is correct. If not, the error is doubled by reversing the set-square and this must be taken into account in trueing it. The right angle must be true before the remaining angles are tested.

(*b*) *To test the* 45° *angle.* Draw a line with the edge AB of the set square as in Fig. 10. Reverse the set square by placing the corner A in position B. If the edge AB in its second position coincides with the line drawn by it while in its first position the 45° angles are true.

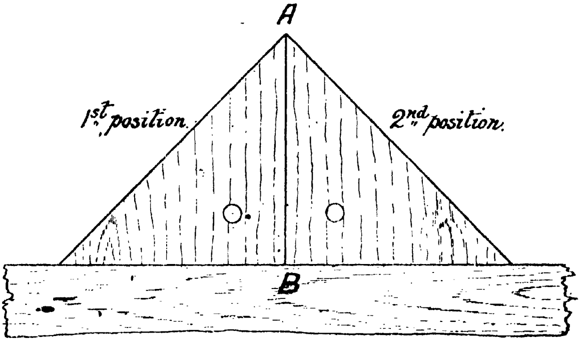


FIG. 9.—Test for 90°

(c) *To test the* 60° *angle of a set square.* Draw a line with the long edge of the set square in position A (Fig. 11). Place it in position B and draw a second line with the long edge. Place the set square in position C. If the long edge coincides with the line EF the set square has a true angle of 60°.

The 30° angle must be correct if the 60° and 90° are true.

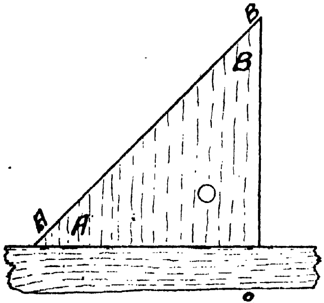


FIG. 10.—Test for 45°.

(*d*) *Simple drawing tests.* Tests for accuracy of instruments and accuracy of drawing can be made by using the 60° set square, in the following way, to draw a hexagon. On a base line set off some easily measured distance, say 3 inches, AB (Fig. 12). With 60° angle of set square draw BC and measure off a similar distance. Repeat till six sides are drawn, if accurate the last side is 3 inches long and passes through A.

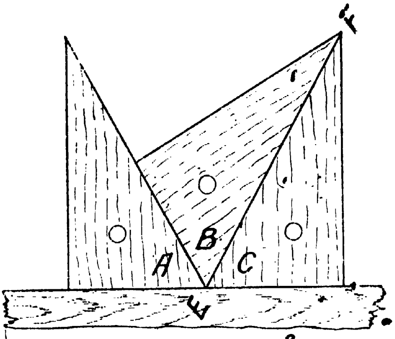


FIG. 11-Test for 60°.

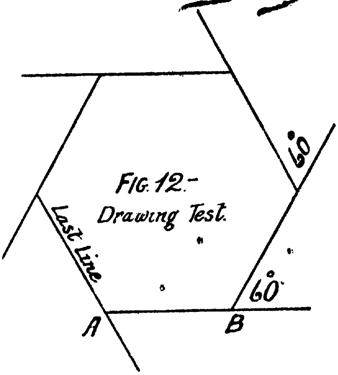


FIG. 12.- Drawing Test.

A similar test for 45° set squares can be made by substituting an octagon for the hexagon.

3. *To test a try square.* Obtain a board with a straight-edge. With the try square in position A (Fig. 13) draw a knife line

on the board. Reverse the try square into position B. If the edge coincides with the line the try square is correct.

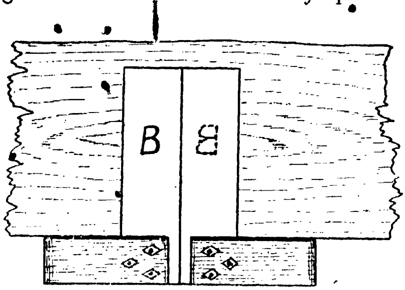


Fig. 13.–Test for Try Square.

THE EVOLUTION OF TOOLS

A small boy who is knifeless cuts a piece of string by placing it on some hard surface and then, with the sharp edge of a piece of stone, braying the fibres apart, or else he rubs the string to and fro on a projecting kerb or rock. You must have seen it done ; you may even have done it yourself before you attained the dignity of possessing a pocket knife or perhaps even the trouser pocket to keep it in.

Imagine a world without tools—all mankind in the condition of our small boy. It needs an effort even to imagine such a state of things, but having effected it the corollary is self-evident ; no tools, no civilisation.

This small boy, with his rude stone cutting tool, represents to us the condition of our remote ancestors when man's aid in overcoming the forces of nature was limited to tools fashioned of stone, wood, bone, horn, etc. The earliest occupants of our own country of whom we have any traces, have left their records in the roughly shaped flint implements, tools, scrapers, etc., which have been discovered in cave deposits.

Few things are more interesting than a study of the primitive methods and the tools by which our early ancestors did their work. As with other inventions, the improvements in tools have resulted from experiments, accidental variations in form, and so on, the useful modifications being permanently retained. The savage who hurt his fist in striking a blow, and the next time picked up the broken branch of a tree or a stone to avoid doing so again, was the originator of a long line of instruments of percussion. The chance splitting of a stone used in this way may have suggested the possibilities of sharp-edged implements for scraping and cutting, and so have led up gradually to our saws, scrapers and files, our chisels, axes, planes, etc.

Flint, by reason of its hardness and the peculiar sharp nature of its fracture, has been the stone most frequently used by savages for making tools. It has played a more important part in the history of civilisation than it is usually credited with. It seems strange to think that here in England the shaping of flints should be carried on to this day. Yet there is one spot, and only one, the little village of Brandon in Suffolk, where gun flints are still made for the African trade, and in its neighbourhood are abundant traces that prehistoric man there delved to obtain a supply of good flint. Shafts sunk into the earth and tunnels burrowed in the chalk are evidences that in very early times suitable qualities of flint were laboriously sought; nay, the very marks were there, on the sides of the cuttings, of the primitive tool wielded by some neolithic craftsman, who shall say what ages ago?

From the celt or flint finished by the chipping process alone, and fixed in a cleft stick or horn, to the ground and polished implement pierced to take a handle, marks an advance, and brings us to the later stone age. Specimens of this period in the British and other Museums bear witness to a high degree of skilful workmanship.

It was the discovery and use of metals though that brought us within measurable distance of civilisation, and this, of course, presupposes a knowledge of fire. Bronze was abundant in the East 5000 years ago, and specimens of the wooden bow-drill for obtaining fire, similar to those used in recent times by savage races, have been found in Egypt. The ancient tools of bronze consist as a rule of nine parts copper to one of tin. This gives a very tenacious metal, especially when hammered on the cutting edges as in axes, swords, and knives. Pure copper does not seem to have been used to any large extent, probably because it is not so easy to cast as bronze. Flint continued in use for many purposes, however, long after the introduction of bronze.

From bronze to iron is only a step in kind; the shapes of tools were retained very closely, indeed it is very surprising to find of what high antiquity many of our modern hand tools are. Coming down to about 800 B.C. we are told the arts had reached a high degree in North Italy, and that the Etruscan workmen of that age possessed the most perfect form of chisels. To quote Mr Flinders Petrie:—"Our mortising chisels and flat chisels with a tang have not received any improvement in the detail of their form for 2700 years."

A history of the development and invention of tools would be the history of the progress of the race. Standing beside some of our modern machine tools one is struck with the marvellous ingenuity of their action; the resistless and relentless power displayed, the delicacy, the accuracy, the quickness, or complexity, according to the purpose they are made to fulfil. Nothing so eloquent or so graphic in this connection has been written, perhaps, as the words Carlyle puts into the mouth of Professor Teufelsdröckh : "Man is a tool-using animal. Weak in himself, and of small stature, he stands on a basis, at most for the flattest-soled, of some half-foot square, insecurely enough ; has to straddle out his legs lest the very wind supplant him. . . . Nevertheless he can use tools, can devise tools ; with these the granite mountain melts into light dust before him ; he kneads glowing iron as it were soft paste ; seas are his smooth highway, winds and fire his unwearying steeds. Nowhere do you find him without tools ; without tools he is nothing, with tools he is all."

In connexion with this subject pupils should be encouraged to visit the nearest museum and see for themselves early examples of tools and similar implements ; or to take advantage of any opportunity that may offer of seeing through local workshops and factories.

"The Story of Primitive Man," by Edward Clodd (Newnes & Co., 1s.), and "Primitive Man," in the Temple Primers (Dent & Co., 1s. net.), have much interesting matter on this subject, and many illustrations. A little handbook recently published by the London County Council in connexion with the Horniman Museum—"From Stone to Steel," price 3d., deals in a concise and suggestive fashion with the Stone, Bronze, and Iron Ages.

LEVERS

Obtain a piece of batten 6 or 8 feet long and three equal weights. Using the back of a chair as a support ask the class so to arrange the batten on it that when one weight is placed at each end of the batten the whole may balance. How far from each end is the support ? Write the distances on the board. Let the batten be now arranged that one end carries one weight and the other two. Again measure the distances from the support and write down as before. Now multiply these distances by the weights. Point out the relation between weight × distance for each end in both cases. Hammers or mallets may be used as weights if nothing else is available. If a boy takes the place of the chair back how great a weight will he be holding up ?

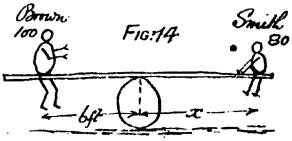


Fig. 14.

The top rail of the chair is the *fulcrum* and is pushing upwards with a force equal to the weight of the batten, which is a *lever*, and the weights on its ends. This is called the *reaction* at the fulcrum.

Ask the class for examples of levers of this kind, where the fulcrum is not at the end of the bar. *Illustrations :* see-saw, crow-bar, pincers, scissors, beam of scales, steelyard.

Two boys of unequal weight are playing see-saw : will they balance ? What has to be done, then ? The lighter boy must have " more pudding " ; in other words, he must move further away from the fulcrum than the heavier boy.

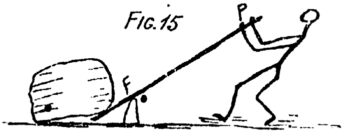


Fig. 15

Brown weighs 100 lbs., and Smith 80 lbs. If Brown is 6 ft. from the fulcrum, how far away must Smith be from it in order that the see-saw may balance ? (Fig. 14).

Brown multiplied by Brown's distance = Smith multiplied by Smith's distance. $x \times 80 = 100 \times 6$. *Answer* 7½ ft.

A crowbar is frequently used for moving a heavy object such as a stone. If it requires a force of 200 lbs. to raise the stone shown in Fig. 15, what effort is required at P to do it when FP is five times the length of the other arm of the lever ?

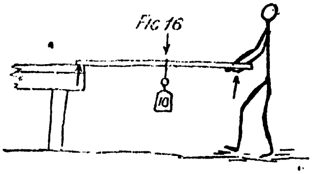


FIG 16

How comes it that a force of 40 lbs. is sufficient to accomplish this ? Explain that the power applied to the end of the bar has to move through five times the distance the stone is lifted, so that what is gained in power is lost in distance. The total work done is the same at each end of the lever.

What is the pressure on the fulcrum in the above example ?

In levers of the second kind the fulcrum is at one end, the power at the other, and the weight between. A bar of wood may be rested with its end on the edge of the bench, and the other end held up by a boy; then hang a ten pound weight at the centre. How much of the weight is supported by the bench, and how much by the boy ?

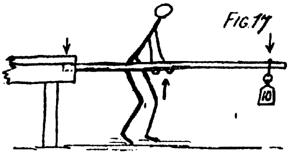


FIG 17

Change the position of the weight on the bar and note the results for the various positions (Fig. 16). Familiar examples of levers of this kind are: Nutcrackers, wheelbarrow, oar when rowing, chopping knife, hinged door, etc. The weight is always greater than the power exerted, because it is nearer the fulcrum.

In the third kind of levers the fulcrum is again at one end, but the weight and the applied power are reversed from those of the second kind. The last illustrations with the bar of wood may again serve our purpose if the end is ledged *under* the bench top (Fig. 17).

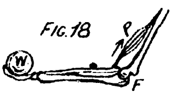


FIG. 18

Examples: Fire-tongs, sugar-tongs, treadle, sheep-shears, spade in shovelling, canoe paddle, safety valve of steam boiler, and the raising of the forearm—where the elbow joint is the fulcrum, the hand the weight, and the contraction of the muscles is the force acting (Fig. 18).

PINCERS

This effective little tool consists of two bent levers working upon a common fulcrum, the pin by which they are loosely riveted together.

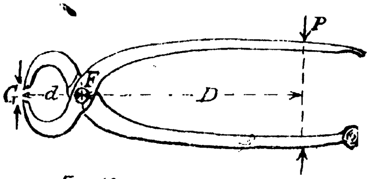


FIG. 19 Pressure between jaws $= \frac{P \times D}{d}$

The act of withdrawing a nail by means of the pincers may best be understood by treating it as a two-fold process. In the first place, the grip on the nail will be greater than the pressure exerted by the hand of the user in the proportion that distance D is greater than distance d, usually three or four times (Fig. 19). In pulling out the nail the fulcrum is the point where the tool is in contact with the wood, and the action of the pincers is equivalent to that of a bent lever NFP (Fig. 20). The pull on the nail is to the downward pressure exerted at P as FP is to NF. The fulcrum changes as the tool is depressed, but the mechanical advantage is roughly about 7 or 8 to 1; and as the power of both arms may be brought to bear on a stubborn nail this means a very considerable force.

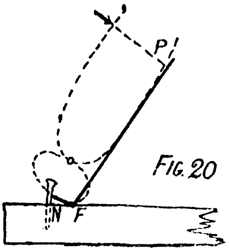


FIG. 20

BOW SAW

The bow saw is another example illustrating the use of the lever. Slacken the twisted cord in order to show the construction of the frame; and call attention also to the way the handles take the strain of the saw-blade. The pull exerted by the twisting of the cord may be approximately found by a spring balance or by loading, and the tension on the blade then worked out by calculation as in Fig. 21. In Fig. 22 this is made clearer by showing one side of the frame as a lever.

The tension on the blade in the example given is 13⅓ lbs., not 26⅔ lbs. This may be shown by taking the case of two boys playing at tug-of-war. If each boy pulls with a force of 100 lbs., what is the tension on the rope? Only

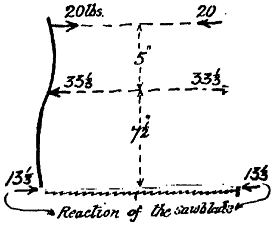


FIG. 21

100 lbs., of course, as one end of the rope might be secured to a post and made to do duty for one of the boys while the other exercises the same pull as before (Fig. 23). What is occurring to the middle bar of the frame ? Such a bar is said to be in *compression.* What is the term used for anything being stretched or pulled at from the ends ? *Tension.* Familiar examples of tension and compression are a clothes line and the clothes prop used to support it.

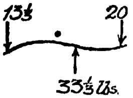


FIG. 22

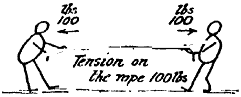


FIG. 23

Show that in using the bow saw the worker exerts a compressive force on the blade. What happens when this force exceeds the tension in the blade set up by the twisted cord ? When is the saw blade most likely to be broken ? What would happen if the frame were tightened up *too* much ?

TOOLS AS LEVERS

In addition to the pincers and the bow-saw which have already been dealt with, there are several other tools and appliances in the manual training rooms which depend on leverage for their effectiveness. It is not thought necessary to do more than mention some of them here : Screwdriver, brace and bit, gimlet, vice and cramp handles, handle of grinding stone, claw-hammer.

THE FASTENINGS OF TOOLS

An interesting and instructive lesson or two may be got by inquiring into how and why different parts of tools are held together.

The handles of chisels and gouges, files, bradawls, and screwdrivers are simply driven tightly on and are kept on by *friction*. The tangs are either square or rectangular in section, to prevent rotation, and are tapered. The handles are provided with ferrules to prevent splitting, and in the case of the screwdriver the ferrule is notched and the tang spread out flat to resist the tendency to loosen under the strain this tool has to withstand.

Friction also holds the wedge of the plane, the handle of the socket mortising-chisel, and the mallet-head.

Examples of riveted fastenings are the try square, gimlet, and pincers—the latter being loose enough to work of course. Call attention to the need of the brass cover plates in the square and the washer of the gimlet. The brass guard on the working-edge of the square has three or four small dowels cast on to it fitting into holes prepared in the stock.

Among the screwed fastenings there are saw handles, bevels, and the adjustable clutch of the American type of brace. In the saw both head and nut are sunk flush with the surface of the wood. This necessitates a notched screwdriver should the screws need tightening. Attention should be drawn to the ingenious contrivance by which brace-bits are firmly held in the brace.

The wedge of the plane affords an example of the *inclined plane*. The same principle is illustrated in the mallet handle and the wedge fastening of the hammer. The screw may be shown to be an inclined plane by winding a right-angled triangle cut out of paper around a cylinder. If a thick line be drawn on the hypotenuse of the triangle the screw will show up very plainly.

THE CUTTING ACTION OF CHISELS

All cutting tools act by reason of their wedge-like form. The angle of the cutting wedge varies greatly with different materials such as wood, iron, steel, etc. In cutting a piece of wood with a chisel the action is a two-fold one. First there are the fibres of the wood to be severed, and second, the cut has to be forced or opened wider so that the cutting action may continue. A sharp chisel will, of course, sever the fibres with less pressure than a blunt one would require. But the total pressure needed in paring depends less upon the keenness of the tool than it does upon its *cutting angle.* Thus of two chisels equally keen, one with a cutting angle of 20° and the other of 30°, the pressure needed will be considerably greater in the case of the latter because the turning over of the shaving which is being cut will be more abrupt than with the longer pointed chisel. It is this opening out of the cut which absorbs most of the effort entailed in the process. The question arises then, Why not have the chisel ground to a very small angle ? It is evident, of course, that such a cutting edge would lack support and would be very easily damaged. It would be of little use to have a chisel with such an edge if one had to be constantly renewing it either on the grindstone or oilstone. The acuteness of the cutting edge is limited, therefore, by the strength necessary for permanence of the edge under ordinary conditions of usage.

Chisels should be ground at an angle of 20° to 25°. Many woodworkers immediately set up a sharpening angle which increases this by another 10°. It is better, probably, that the newly-ground tool should be sharpened so that the grinding angle and the sharpening angle practically coincide.

See the lesson on the Grindstone in Chapter VII. on the need for regrinding tools.

STRIKING TOOLS—HAMMER AND MALLET

The heads of the hammers used in the manual training room weigh from 8 to 12 ozs. The head is steel, the face of the hammer being hardened so that it may not be injured by striking nails, etc. If it were used for striking tools made of steel as hard as itself, the face would sooner or later get damaged. To avoid this, the part of the tool which is to be struck should be left soft; for example, "cold" chisels and nail punches are tempered hard at their points only.

The mallet is used for striking tools with wooden handles, such as the chisel. If a hammer were used in mortising, for instance, the chisel handle would not last nearly so long as it does where a mallet is employed. Nor would it be so effective. Strange as it may at first sight appear, of two blows of equal force, the one with a hammer and the other with a mallet, it will be found that the latter drives the chisel deeper into the wood than the blow of the hammer does. The nature of the two blows is quite different. The impact of the hammer is sharp and decisive and the force of the blow almost instantaneously spent; whereas the softer and more yielding mallet deals a duller blow, parting with its force less rapidly and allowing more of the impulse to travel down to the point of the chisel than in the case of the hammer blow. The two cases may be likened to the jolts experienced by one in a vehicle without springs and one with springs in travelling over a road full of ruts.

When a nail is driven into a piece of wood by means of a hammer, the resistance offered to the momentum of the hammer is the friction between the nail and the fibres of the wood, that has to be overcome as the nail penetrates deeper and deeper. Everyone knows that a large force is needed to pull out a long nail, and of course it must need a greater force to drive it in. How is it then that a comparatively light hammer will accomplish this? It is because the blow can be given with great velocity. A rapidly moving mass, such as a hammer head, brought suddenly to a stop by striking something, expends very considerable force. If it is stopped more gradually the force will be less. Hence the force of the blow depends upon the amount of movement the nail, or whatever else is struck, makes. If the blow causes the nail to penetrate deeply into the wood the force exerted will not be very great; but, assuming the velocity of the hammer to be the same, if the nail is driven only a very little distance the amount of resistance offered will be considerable. Let us take an example to illustrate this.

Suppose a hammer weighing one pound is moving at a velocity of 20 feet per second at the instant it strikes a nail. A study of the laws of mechanics will show the amount of energy in a falling body to be the weight of the body multiplied by $\frac{\text{velocity}^2}{64}$.

The kinetic energy then, will be $\frac{1 \times 20 \times 20}{64} = 6\frac{1}{4}$ ft. lbs.

Suppose the blow results in the nail being driven $\frac{1}{4}$ inch deeper into the wood, it is evident that the energy of $6\frac{1}{4}$ ft. lbs. has been used up in the process, action and reaction being always equal and opposite. So the force of the hammer multiplied by the movement of the nail (in feet) $= 6\frac{1}{4}$.

If x represents the mean resistance of the nail then

$$x \times \tfrac{1}{4} \div 12 = 6\tfrac{1}{4}$$
$$x = 300 \text{ lbs.}$$

If the nail had yielded only $\frac{1}{8}$ inch, the effect of the blow would be 600 lbs., this being the mean resistance offered by the nail in penetrating that distance. In practice the conditions here assumed could not be actually determined. The example is merely illustrative.

PLANES

The Jack plane, Trying plane, and Smoothing plane are called the bench planes, because they are in constant use on the bench. A craftsman uses the jack plane for roughing out only, trying or "trueing up" the work afterwards with the trying plane. The jack plane iron is therefore sharpened with the cutting edge well rounded as in Fig. 24, this being the best form for attacking the rough surface of the wood or for reducing the material where much has to be planed off.

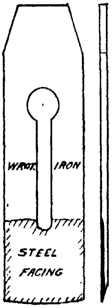


FIG. 24

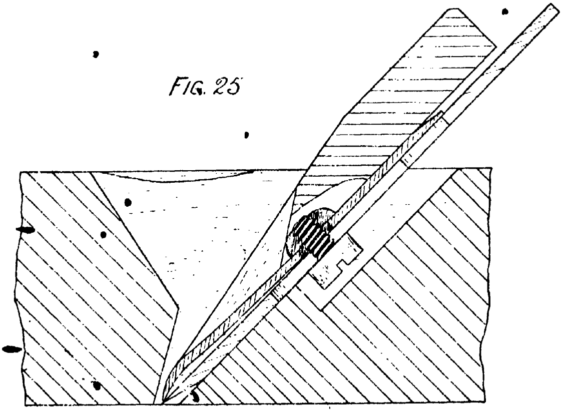
In the manual training room, where most of the work is small, the jack plane may be used both for commencing and finishing the planing, seeing that the larger trying plane would be unduly heavy for young boys. In order that the plane may give a fairly accurate finish, the rounding of the cutting edge should be much less than that allowed by the workman. The Smoothing plane, as its name implies, is used for smoothing and cleaning up finished work. Except for a very slight rounding of the corners both smoothing and trying planes should have perfectly straight cutting edges.

How did the Jack plane come by its name?

Probably it is so called because it is the "jack of all work" in the way of planing. Examples of a similar use of the word "jack" are numerous: Jack tar, boot-jack, meat-jack, lifting jack, jack-of-all-trades, etc.

Beech is the wood almost invariably used for planes, as indeed it is for most other tools. A plane requires a timber which will wear well and evenly under the condition of constant rubbing it has to stand when in use. Beech, by reason of its uniform texture, is found to keep a smooth, even surface; and it wears away so slowly, that a plane lasts a lifetime when carefully used. The sole of the plane should be at right angles to the direction of the medullary rays; and the nearer these rays on the end of the plane approach to parallel vertical lines the better. Planes should be made from selected and well-seasoned stuff. A periodical dressing of raw linseed oil will add to the smoothness of working and durability of planes.

FIG. 25



When giving a lesson on the plane a longitudinal section should be shown (Fig. 25), or better still a worn out plane may be sawn down the centre. The angle the plane-iron makes with the sole, 45°, is then clearly seen, as well as the mouth and the shape of the "throat" or escapement.

The plane-iron is wrought iron, with a facing of steel welded on the part containing the cutting edge and extending up to the slot for the screw of the cap iron

(Fig. 24). The line of the weld may generally be seen and the boys should be asked to notice it. A newly-ground plane iron shows clearly the silvery white colour of the steel and the bluish-grey of the wrought iron. The characteristic properties of these two metals are dealt with in a later lesson.

Plane irons are ground to an angle of 25° to 30°, rather greater than the angle of chisels, as they have to resist a force acting at 45° instead of in the direct line of the blade. A blade made entirely of steel would take longer to grind and would also need the top end letting down to a softer temper to avoid damaging the face of the hammer.

The cap iron or cover iron, sometimes inappropriately called the back iron, is curved over at the lower end and brought to a fine, but not a cutting edge. It is made entirely of steel, so as to act as a stiff spring when tightly screwed against the blade. The cap iron serves a double purpose. In the first place it braces up the thin cutting-edge of the plane iron, making it more rigid and better able to withstand the shock of contact with hard knots, etc.; and it also turns over and "breaks" the shaving as soon as it is cut and thus lessens the liability of the fibres tearing up when the timber is cross-grained. So far as the second purpose is concerned there would be no use for the cap iron if all wood were perfectly straight grained. The nearer the cap iron is set to the cutting edge, the less tendency there is for the fibres to be torn up. The jack plane is generally set with the cap iron $\frac{1}{16}$ inch away for manual training work, but the artisan's would be about $\frac{1}{8}$ inch. Smoothing and trying planes are set finer, about $\frac{1}{32}$ inch or even less, in order to take out any roughness left by the jack plane.

It may be asked, Why not set the jack plane cap iron only $\frac{1}{32}$ inch back, if it has the effect of giving greater smoothness? The answer is that greater labour would then be required to push the plane, as the shavings offer more resistance to the plane the nearer the cap iron is to the cutting edge. The increased labour is not present to such an extent in the smoothing plane as so little has to be taken off.

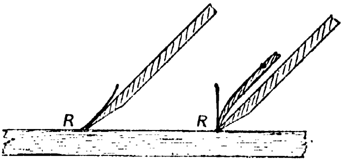


FIG. 26 – Effect of Cap Iron

It is somewhat difficult for young boys to understand the function of the cap iron, and especially to realise that a thin shaving may act as a lever prising up the wood just in advance of the cutting iron. The cap iron is not the only factor, however, in preventing this lifting up of the fibres where they rise towards the advancing plane, as seen at R, R in Figs. 26 and 27. A plane with a narrow mouth holds down the shaving as it is being cut, whereas one with a wide mouth leaves a clear interval for uninterrupted tearing up (see Fig. 27). Hence the need for "remouthing" a plane when the opening becomes wide, owing to wear and the occasional trueing up or "shooting" of the sole of the plane.

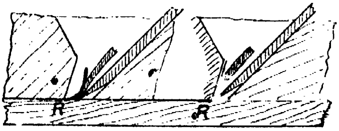


FIG. 27 – Effect of Wide Mouth

Why does a blow of the hammer or mallet release the wedge of a wooden plane? By the sudden shock that the body of the plane receives from the mallet it is forced suddenly forward, while the irons and the wedge are as unaffected by the blow as is the penny in the familiar trick where a visiting card is suddenly flicked from under it, leaving it undisturbed on the end of a stick (Fig. 28). A chisel handle knocked when held firmly in the hand in order to drive it on to the blade, and the end of a broom handle hit in a similar way to drive it into the head, furnish other examples. These illustrate what is called "Newton's first law of motion," to be found in every book on Mechanics.

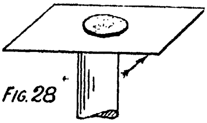


FIG. 28

The infinitesimal opening out of the wedgeway of the plane under the bending influence of the blow, together with the loosening effect of the vibration caused by the impact, also aid in setting free the wedge and blade.

SAWS

In the section of Chapter VII. dealing with the Art of Questioning, it is shown that the thinner the saw blade, provided it has enough stiffness to take the thrust without bending, the greater the efficiency of the saw. The saws used by the Chinese and Japanese are much thinner than ours because they are drawn towards the operator when sawing, and the blade is therefore in tension during the working stroke. The advantage thus gained, however, is probably more than counterbalanced by the disadvantage of using the saw by pulling instead of thrusting (Fig. 29).

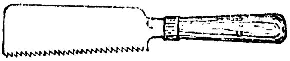


FIG. 29 - Chinese Saw.

The shape of our saws is determined by the fact that they must resist any bending tendency; thus the blade is made much wider near the handle, where the bending is likely to occur. To give clearance the teeth are "set," *i.e.*, the teeth are slightly bent outwards one to the right, the next to the left, and so on alternately, as may be readily seen by looking across the blade from the back edge. Just enough set to provide clearance for the blade should be given; too little will cause undue friction, while an excess of set will make a wide cut and so entail increased labour and waste of material.

The set is given by striking every other tooth with a very narrow paned hammer while the saw rests on a block of iron with a slightly rounded edge held in the vice. This method requires much skill, however, and can only be properly executed by an expert. An easier way for the less skilful is to give the blows with a hammer and nail punch, the saw being supported by a block of hardwood or a piece of sheet lead resting on a solid surface. When alternate teeth are bent in one direction, the saw is turned over and the remaining teeth are set in like manner. A patent "saw-set" may also be used.

After the saw has been set, it is next sharpened by being filed across with a triangular file having angles of sixty degrees. The purpose of the saw determines the method of filing and also the shape and number of teeth per inch. A rip saw for cutting or ripping along the fibres of the wood has about four points in a length of one inch (three complete teeth). Its cutting edge is at right angles to the fibres and it severs the wood in one place, each tooth acting like a narrow chisel held vertically, the teeth being filed square across the blade (see Fig. 30).

The action of the teeth of a cross-cut saw is different; the teeth are filed across at an angle, giving a cutting edge on the outside of each tooth, so the wood is severed on *each* side of the saw and the waste material between—the sawdust—dislodged by the thrust of the saw (Fig. 31). The number of teeth is more than in the rip saw, about five or six points to an inch being customary.

The "nib" or slight projection on the back edge of the point of the saw, about which most boys are so curious, has no practical use whatever, it serves merely to relieve the straight line of the back and is sometimes left off.

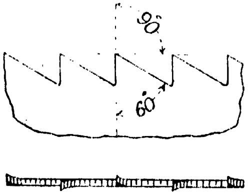


FIG. 30 - Rip Saw Teeth

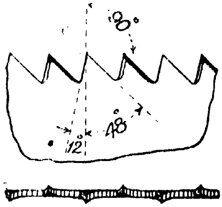


FIG. 31 - Cross-cut Teeth

Tenon and dovetail saws are used for finer work than the others, and as the blade in these saws is both thinner and narrower it has to be stiffened by a thick band of brass or iron bent to grip the back edge of the blade firmly. The teeth are correspondingly fine, from ten to sixteen points to an inch. As the tenon saw has to work both with and across the grain there is less angle in filing across the teeth than is given for the cross-cut, and very little set is required.

IRON AND STEEL

Using the word in its widest sense we may say that iron is made in three varieties: cast iron, wrought iron, and steel. Although these three metals differ very considerably in their characteristics, they all have the same original source, namely, iron ore.

The iron ore, or ironstone, when taken from the ground is generally of a reddish brown colour; it is combined with oxygen and carbonic acid, and has clay and other impurities mixed with it. The first process the ore undergoes is that of *roasting*. This is done in a kiln; the moisture, sulphur, and carbonic acid are driven off, and the ore is then ready for *smelting* in a *blast furnace*. These furnaces are huge affairs, being 70 to 80 feet high, and about 24 feet diameter inside. They are built of iron plates strongly bound together and lined inside with a thick wall of firebricks and fireclay. The ore is mixed with coke, a little limestone to act as a flux in ridding the ore of earthy matters, and the whole subjected to a current, or *blast*, of hot air which brings the furnace to a high temperature and melts the iron. The molten metal, being heavier than the coke and limestone, sinks to the bottom of the furnace, and when sufficient has collected there is run out through a small hole (*tapping hole*) into a long mould or channel of sand, called the *sow*, with numerous channels branching out from each side, called *pigs*; hence the term *pig iron*, from a fancied resemblance to a sow and litter of little pigs. The tapping hole is then plugged up with a piece of fireclay, which quickly bakes solid and closes the furnace. The earthy matter fuses with the limestone into a glassy substance called *slag*, which is run off from a hole higher up in the furnace.

Cast Iron. The bars of pig iron are D-shaped in section, about 4 inches across and a yard long, weighing somewhere near a hundredweight. These are remelted in a cupola furnace and poured or *cast* into sand moulds, made by means of wooden patterns shaped like the required casting.

The chief difference between cast iron, wrought iron, and steel is in the amount of carbon combined with the iron. Cast iron contains more carbon than the others, from 2 to 5 lbs. in 100 lbs. (2 to 5%), causing it to be brittle, and therefore not tenacious. It is very rigid and strong, however, when used in compression, and may be cast into intricate machine parts, such as lathe beds and headstocks, stands of grindstones, etc., which would be difficult to forge. It is crystalline in structure; *not* malleable, *not* ductile, *not* weldable.

Breaking strength— 40 to 45 tons per square inch in compression.

7 to 10 tons per square inch in tension.

MALLEABLE CAST IRON. Small articles, such as iron planes, etc., made of cast iron are rendered somewhat malleable by being packed in powdered hæmatite in iron cases and heated to a cherry-red heat for a few days. This process burns off some of the carbon from the surface of the cast iron, rendering the outer part tougher.

WROUGHT IRON is made from cast iron in what is called a *puddling* furnace, the object being to get rid of the carbon contained in the pig iron. White hot, pasty masses of metal, weighing about 80 lbs. each, are formed into balls in the furnace and next worked under a steam hammer to squeeze out the cinder or slag and weld the particles together; finally, the slabs are passed under heavy rolls. The iron is improved in quality by being reheated and again rolled.

Wrought iron has only ¼ lb. carbon in 100 lbs. (.25%). It is fibrous and stringy in texture and very tough. A bar 8 inches long will stretch 20 to 25% before it breaks. Wrought iron is *malleable,* may be forged at red heat; *ductile,* may be rolled into plates, bars, rods, etc.; *weldable,* pieces may be joined together by hammering at a white heat. Notice the contrast between cast and wrought iron in these respects. Pincers, pliers, iron vices, cramps are wrought iron. Wrought iron rusts rapidly unless painted or otherwise protected.

Breaking Strength—20 to 25 tons per square inch in tension.

16 to 20 tons per square inch in compression.

STEEL may be made either from cast iron by first getting rid of the carbon and then adding the necessary amount, or from wrought iron by adding more carbon to it. The latter process is termed *cementation.* Bars of wrought iron are embedded in charcoal and exposed to a high temperature for a period of four to seven days. The longer the period the greater the amount of carbon taken up by the iron. For tools required to take and retain a keen cutting edge, ten or more days are needed, by which time the amount of carbon will be 1.5%.

Mild Steel, containing .15 to .3% carbon, is produced direct from pig iron by the Bessemer and the Siemens-Martin processes; it has the same qualities as wrought iron but is 20 to 25% stronger. It is used for girders, bridges, boiler plates, tram and railway lines, etc.

Tool Steel contains 1 to 1.5% carbon and may be *hardened* and *tempered.*

Between these extremes of mild and tool steel there is a wide range of varieties. Steel may be welded when there is not much carbon in it. When the carbon is in large proportion, steel may be melted and cast into moulds in the same way as cast iron. Tool steel is treated in this way to obtain a more even mixture of the carbon. Great care is needed when forging tool steel. The texture of steel varies from fibrous to crystalline.

Breaking Strength—27 to 30 tons per square inch in tension and compression.

TEMPERING and HARDENING STEEL. If tool steel be heated to a bright red and cooled suddenly in water, it has the remarkable property of becoming extremely hard and brittle. The degree of hardness varies with the composition of the steel. If it is made red hot and allowed to cool gradually, it remains soft and may be easily cut with a file or chisel.

Closely akin to the hardening process is that of tempering. The hard steel may be reduced to any degree of hardness by reheating to a certain amount and then cooling. This is known as *tempering*. If you take a piece of hardened steel and either grind or rub it bright it can be tempered in the following way. Place the steel on a piece of red hot metal, or in a clear fire or gas jet, and you will notice a band of colours appear. First, the colour will be a very pale yellow, then light straw colour, dark straw, brownish yellow, brown, purple, bright blue, deep blue, blackish blue. These colours are due to the formation of a thin film of oxide on the clean surface of the metal during its gradual reheating, and indicate for us the temperature of the steel at the several stages.

Supposing we are to "let down" or temper the piece of hardened steel for a tool, it will be cooled off when it reaches the colour representing the proper degree of hardness for the work it has to do. Thus when the pale yellow appears the temper is right for files and lancets, where great hardness is required; brownish-yellow is suitable for penknives, punches, etc.; brown for scissors, cold chisels, plane irons; purple for axes, chisels and shears; blue for springs, saws, and screwdrivers, which require toughness and elasticity.

Instead of the above method a process known as point hardening is often used. By this method the hardening and tempering are done in one operation. The tool is made red hot at the point for a distance of about 2 inches, and then dipped in water for $\frac{3}{4}$ of an inch or 1 inch, leaving enough heat in the remaining part to travel back towards the point of the tool. The cooled end is rubbed with a piece of sandstone, a piece of broken grindstone for example, and then carefully watched till the right colour appears, when the whole tool is plunged in water till it is cold.

For small objects, such as penknives and small springs, a metallic bath of varying proportions of lead and tin is used. The articles are placed in this bath and then taken out and cooled off, a uniform temper being thus secured.

A piece of clock spring may be used to show a class how steel may be hardened and softened by holding it in an ordinary gas flame and cooling it off first suddenly and afterwards gradually. The colours may be noticed on the part which has been near the flame.

NAILS

Out of some 300 varieties of nails those most useful for the manual training room are (*a*) Cut nails ; (*b*) Wire nails ; (*c*) Oval brads and panel pins ; (*d*) Brass pins.

Cut nails (Fig. 32) are stamped from sheets of mild steel. These nails have a great power of holding in the wood. They are made in sizes from 1 inch long up to 6 inches.

Wire Nails. For general purposes wire nails are made of the pattern shown in Fig. 32. The objection against them is the size of the hole made by the head when punched below the surface of the wood. Though the shank is cylindrical these nails retain a firm hold. Sometimes the shank is made square in section or even slightly twisted. In all cases these nails are, as their name implies, made from wire. Ingots weighing from 80 to 200 lbs. are prepared and reduced to " wire rods " in rolling mills. These rods, of about $\frac{1}{5}$th of an inch in diameter, are reduced to the gauge of the nail by " drawing." Drawing consists in passing the rods through hard steel drawplates, the holes in the successive plates being diminished in size so that the wire is gradually reduced. Drawing is performed with cold wire, but heat is necessary in rolling the rods from the ingots. All sorts of metals are thus drawn into wire, diamonds and rubies being used for the drawplates when the wire is required to be extremely fine, gold wire for example.

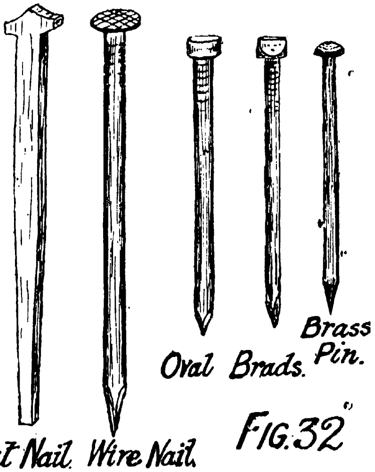


FIG. 32

In the case of nail-making the wire is fed into a machine which automatically straightens it, cuts it into lengths suitable for nails, points them, and also makes the heads either by percussion or by pressure. Machines are capable of turning out from 100 to 300 nails per minute and have entirely superseded the making of such nails by hand. Wire nails can be had from $\frac{3}{8}$ of an inch up to 6 inches long.

Oval brads and panel pins are also made from wire, the shape and size of their heads make them suitable for fine work. The oval brad (Fig. 32) is easily driven in the wood, the smallest diameter should be at right angles to the grain. The panel pin has a fine round section that makes it suitable for such purposes as fixing mouldings round panels, and nailing together small models. Oval brads can be obtained in sizes from ½ inch up to 3 inches long.

Brass pins (Fig. 32). These are round-headed nails made from brass wire. The heads are allowed to project above the surface of the wood and form an ornamental feature, or the pins are used as pegs for keys, etc., to hang on. Those about 1¼ inch long are most suitable for the manual training room.

Brass is an alloy consisting of two parts of copper and one of zinc. The cheaper brass contains more zinc.

SCREWS

Wood screws may be of either iron or brass and vary in length from ¼ inch to 6 inches in length. Each size is made in a number of different diameters to suit various requirements. Holes for screws should be bored equal in diameter to that of the shank of the threaded portion of the screw and countersunk for the head. In very hard woods the top end of the hole should be enlarged to fit the unthreaded part of the screw fairly tightly. This will prevent splitting of the wood when the screws are driven near to the end. Brass screws require careful handling in hard wood or they will break off owing to the lesser strength of the material.

Round headed screws are used when it is desired to leave the head of the screw standing above the surface of the wood.

GLUE

Glue was known to the Egyptians more than 3000 years ago and was used by them in veneering woods.

Glue is made from skins and other tissues, cartilage, hides, bones, fish scales and bladders, and all sorts of refuse odds and ends, by boiling them down with water and cooling and purifying the resulting liquor. The materials used are soaked in water to which either lime or soda has been added to remove the fat and dirt adhering to the skins, etc. This soaked material, after the lime has been removed, is known as "stock." The glue-stock is boiled for a considerable time and when reduced to a jelly run into zinc moulds to cool. Any colouring material required is added during the boiling process, as are also materials for clarifying the liquor. By the modern plan the moulds form blocks about 6 inches thick, these when sufficiently cooled being cut into the thin cakes of commerce by means of a frame containing a number of wires, through which the moulded block passes.

These thin cakes are further dried on open-work shelves which permit of the air coming in contact with every part of their surface. The drying process is said to be one of the most delicate operations in glue-making, warm air being used for this purpose in most modern glue factories.

For woodwork the three principal varieties of glue are those known as Scotch, French, and "Town." Much inferior glue is obtained by boiling the "stock" a second or even a third time; each time the liquid is drawn off and fresh water added. Scotch glue is the strongest of the three varieties named. French glue is made in thinner sheets out of more carefully prepared materials and is clearer and lighter in colour than Scotch glue.

Town glue is quite inferior to either French or Scotch.

Tests for good glue include the following. The cakes should be clear, without smoky looking patches when held up to the light. When wetted and rubbed glue should feel sticky, a greasy surface indicating inferior glue. When tapped the cakes should give out a clear sound and not a dull one like leather. If broken the fracture should be sharp and bright. An inferior glue will absorb less water than a good one. The smell of good glue is not musty or objectionable.

LESSON ON PREPARING AND USING GLUE

How would you prepare a pot of glue? *Get some glue, break it up into small pieces, and cover it with water.*

In this condition it may either be boiled at once or stood by to soak. It dissolves more quickly if soaked overnight. Would you put the pot containing the soaked glue directly on the fire or over the gas? *No.*

Elicit that the water jacket prevents the temperature of the inner pot from being raised beyond the heat of steam, and so the glue is not burnt as it would be if the moisture were driven from it rapidly at a higher temperature.

Glue loses some of its strength every time it is reheated. Therefore do not make too much at once.

In making joints with glue in what condition should the glue be—thick or thin?

Show that thin glue will not hold well, and thick glue cannot be rubbed out of the joint.

Why do we rub the joint? Elicit that it is for the purpose of forcing the glue well into the pores of the wood and getting the surfaces close. A large number of small glue-dowels are thus formed.

Glue must be used quite hot, and of such a consistency that it will run off the brush, if dipped into the glue and held up, without breaking into drops.

GLASS-PAPER

Glass-paper is made by crushing glass under a revolving stone and putting it through sieves to ensure all the particles being about the same size. The paper is prepared for the glass by a thin coating of hot glue over which the powdered glass is dusted with a sieve. As at one time fine sand was used in the place of glass this commodity is often called sand-paper.

EMERY-CLOTH

Emery-cloth used for cleaning tools is manufactured by dusting fine emery powder over cloth that has been coated with liquid glue. Emery-paper is paper prepared in the same way. The cloth stands the rubbing better and so is more generally in use.

OILSTONES

There are several varieties of oilstones in use, among which are Arkansas, Washita, Turkey, Charnley Forest, and Canada.

Arkansas oilstones are compact, fine-grained stones, white in colour, and of fairly even quality.

Washita stones are yellowish-grey in colour, not so fine as Arkansas, but cheaper, and satisfactory stones when of good quality.

Turkey stones vary a good deal. They are close-grained, cut easily, but are liable to wear very irregularly. The best make really good oilstones, but the inferior are not so useful as the two varieties above.

Charnley Forest is of a greenish-slate colour and very slow cutting, but puts a fine edge on tools, and is useful as a finishing stone for tools requiring a very fine edge.

Canada stone represents a type of stone artificially made. Such stones are liable to be open grained and wear away easily. With this class of stone a really fine edge is not obtained, but they have the advantage of cutting the iron down quickly. It is advisable to finish on a good leather strop after using the oilstone.

Oils for oilstone—Neat's foot and "sweet" oils are considered best for use on oilstones. To keep the stone clean the addition of about 10 per cent. of paraffin oil is sometimes recommended. Olive oil proves a good substitute for these. *Other lubrications* said to be effective are vaseline, soap, and half lard oil and half paraffin oil. The soap is applied with water, the stone being wetted and rubbed with soap and more water applied till a lather is formed. This is allowed to dry, all that is necessary being the application of a small amount of water during the sharpening process.

To keep oilstones in order they should be frequently rubbed flat. This can be done on a piece of emery-cloth glued to a board, or on a piece of plate glass by the aid of emery powder. A flat stone will answer the same purpose, either coarse emery powder or sand being used and wetted. A good size for an oilstone is about 8 inches long and 1½ to 1¾ inches wide.

INDIARUBBER

Indiarubber in the form best known to the schoolboy, is the manufactured product of certain trees growing in tropical climates. The crude material from which indiarubber is made, exudes from an incision made in the bark of the tree in the form of a milky juice. This juice is caught in vessels suspended below the incisions and coagulated by exposure to the air or by being worked on a wooden paddle over a smoky fire, the latter method giving it a dirty brown colour. The crude rubber is next boiled with water and passed between grooved rollers to wash out the sand, dirt, etc. The resulting sheets of rubber are then dried and taken to the grinding mills, where they are passed between steam-heated iron rollers in order to destroy the fibre and make the rubber fit to receive the mixing compounds. For best rubber sulphur is used, zinc white, chalk, etc., being substituted in the cheaper varieties. The mixed rubber is rolled out into thin sheets and vulcanized by being placed between two steam-heated cast-iron chests and applying pressure. Vulcanized indiarubber owes its colour to the substance with which it has been mixed, lamp-black giving it a black colour. It is used for tyres of vehicles, hose for liquids, rollers, bicycle pedals, etc.

PENCILS

Graphite, from which the best lead pencils are made, is obtained from Borrowdale in Cumberland, from East Siberia, Ticonderoga (U.S.A.), Canada, and Bohemia. The graphite, mixed with clay, is forced through a die while in a plastic state. Grooved slabs of wood are prepared to receive it in lengths suitable for pencil making. A second grooved slab is glued on to the first, when full of leads, and the whole placed in a press to dry. The finished pencils are produced by placing the wood so prepared in a moulding machine which successively moulds the top and bottom of the leaded wood, thus forming a number of separate pencils.

References—

"Tools for Engineers and Woodworkers," by Horner (Lockwood, 9s. net.); R. H. Smith's "Cutting Tools"; Disston's "Handbook on Saws" (Disston & Sons, Philadelphia).

CHAPTER XI

DRAWING

"The drawing should be carried on with constant reference to the shop-work, which it is designed to assist, and from which in turn it will receive assistance. As educational agencies, drawing and construction belong together as two parts of one whole. Neither is fully efficacious without the other. Like the two blades of a pair of scissors, each requires the aid of the other to do its work."—Quoted in "Manual Training," by PROFESSOR WOODWARD.

"Drawing is the most important of all means suggested for the training of the hand and eye; its practical uses in industrial life are universally recognised and, as mental discipline, its value is attested by the stimulus it affords to the accurate observation of things. As a universal language it ought to be taught to all. By writing we are understood by those only who know the language in which we write; but drawing affords a means of expression which all who run may read. To the artisan, drawing is essential that he may be able to receive or to give instructions and to properly understand his own work. To be taught to draw is as essential to a child who is to be employed in any one of the mechanical arts as to be taught to speak and to write. It is one of the three modes of expression which everyone should have the opportunity of learning."—SIR PHILIP MAGNUS.

MAN invented drawing so many ages ago, that history is silent concerning the date of its origin. That man in the Palæolithic age so amused himself is witnessed by the specimens of his art now treasured in our museums. Out of the primitive art of drawing grew the art of writing, which at first was a kind of "shorthand."

drawing, graphic rather than conventional. The first attempts at drawing were naturally crude and resembled in their crudeness the child's early efforts at picturing the things that lie around him. From such simple beginnings has sprung drawing in all its many forms, both freehand and mechanical.

The modern child grows up surrounded by pictorial representations of one sort or another—books, pictures, and posters—and thus becomes to some extent familiar with drawings from a very early age. Drawings and illustrations now play a most important part in our everyday life. Newspapers and magazines are making more and more use not only of pictures but of diagrams, plans, and other graphic and schematic methods of illustration requiring a trained eye to read them. Skill in interpreting drawings of this kind is fast becoming imperative to all who desire to keep in touch with the scientific and mechanical progress of the world. While to the " man in the street " some knowledge of the principles of projection is thus necessary for the better understanding of the wonders of the world, it is to those who follow an industrial or professional occupation that this knowledge proves of greatest service, if indeed it is not indispensable.

From this practical and utilitarian standpoint the ability to make and understand drawings will strongly appeal to those who value education in proportion to its usefulness in after life. From the educational side the value is equally great, and no scheme of handwork is complete unless closely connected with it. Apart from its value in cultivating the intelligence, the act of drawing in itself constitutes a valuable form of hand and eye training.

Our pupils will already have done something in the way of drawing before entering the manual training room, but the drawings will now have an added interest because what is drawn is afterwards to be *made.* In spite of this added interest, however, boys naturally look upon the drawing lesson as of quite secondary importance compared with the tool-work. Anything, therefore, which emphasises the value of understanding thoroughly this "shortest of shorthands," this "universal language," as drawing has been aptly termed, should be taken advantage of. When a few drawings have been made, it may be pointed out how difficult it would be to describe fully in words some of the objects they have drawn.

In one way or another almost every pupil is certain to find the ability to read a drawing a desirable accomplishment. Whether he rides a cycle, drives a motor car, or trudges afoot on the king's highway—a risky thing nowadays—he is sure to find a map useful. From the plan of a model to the plan of a stretch of country, or *vice versâ,* is not too far a cry. Boys are invariably interested in knowing how their school studies are of use in everyday life. Such references should arise naturally, however, from the work in hand and not be "dragged in" indiscriminately. The teacher's own personal experiences will always yield the best illustrations. For instance, one of the writers was called up as a juror at the Law Courts in the Strand, and for two days was engaged in unravelling the conflicting details of a smash-up between two motor cars. Photographs of the road from different points were freely used to elucidate the evidence, but a *plan* of the road and a *section* showing its contours played a far more important part in conveying an idea of the scene of the accident. Judge, counsel, and the twelve "highly intelligent jurymen" repeatedly bent over these four feet sheets of drawing paper as the case proceeded. And so in innumerable other unexpected ways drawing touches everyday life.

In the section dealing with the woodwork course the way in which the drawing may be presented to the pupils will be briefly treated. In this chapter enough explanation of the theory of elementary projection is given to enable the teacher to understand the principles upon which the drawing lessons are based.

But it must ever be kept in mind that the *pupils* do not start with an understanding of these principles, the knowledge of which is so imperative to the teacher. And further, there is no reason why the scholar's comprehension of them should be other than vague in the early stages of the work. A knowledge of drawing is very similar to a knowledge of reading, it comes gradually. If the drawings are made from actual models supplied by the teacher for this purpose, or if the model is otherwise accessible for guidance, it will be found that the whole process will gradually grow clear in the pupils' minds from constant practice. This does not mean, of course, that the pupils are not to be instructed in the theory of drawing; it means that the conceptions involved should be allowed to grow in the minds of the pupils as a result of their own activity rather than be forced upon their attention before they are ready for them. In this way the correct relationship of drawing and woodwork will be established in a natural and easy manner. Never mind if at first the *plan* is spoken of as the "top view" of the object. Because your knowledge of the theory of projection has taught you that such a definition is not strictly accurate, is no reason why it may not be suitable for your scholars.

At the outset, demonstrate on the blackboard or on a sheet of drawing paper how to build up the drawing from a model. When the drawings are made let the pupils *work* from them; let the model from which the drawing has been made be put aside and only brought out to clear up a difficulty if such should arise. That is, show right from the first that the drawing is made for a purpose—to be worked from.

When a few drawings have been prepared in this way and the pupil has got used to the method of drawing the necessary views, he should next be asked to make a freehand, dimensioned sketch of the model to be made. The model should then be taken away and a finished working drawing be prepared from the sketch only. The boy will quickly realise that careful measuring and accurate observation are needed if he should come to a standstill, and find himself obliged to ask for another look at the model owing to omitted measurements or other incomplete details. He will also soon realise that some discrimination is required in choosing the most suitable views to show the object properly and avoid ambiguity of interpretation. The drawings made by the pupils in this way may lack the finish that can be obtained when following the teacher's drawing on the blackboard line by line, but the knowledge gained will be incomparably greater.

At a later stage the pupils should be expected to work from sketches alone or from large diagrams, without the aid of a model to help them in conceiving the shape shown by the drawing. Till this power to work from the abstract drawing to the concrete model has been acquired, the pupil has not realised to the full the true inwardness and meaning of a drawing. This has been the teacher's aim from the first, that the pupils learn readily to conceive the shape and character of an object from a consideration of drawings such as are used in the industrial world. The ability to do this is no mean gift.

It will be found that drawing has special value as a mental training. To represent even the simplest forms by means of lines on paper demands close attention, observation, and the exercise of imagination. Not only has the general nature of the object to be noticed and reproduced, but the correct proportions of the different parts and their relation to the whole have to be clearly realised. At no time probably is the attention so closely concentrated as when considering an object from two or more different but nearly-connected aspects. Thus, for example, when a boy draws from a model his attention is constantly alternating between the thing itself and representing it on paper.

Imagination will be strengthened as the pupil gradually learns to do without a model to work from, and to conceive from a sketch, drawing, or verbal description the full details of what he is about to make. The boy who has learnt to imagine readily the shape of a piece of wood from its projections on paper, has made a start towards the power that can build up finally the conception of the most intricate structure or machine from a study of its working drawings. This ability to interpret from drawings the ideas and inventions of others and to express one's own mechanical ideas by the like method, is akin to the possession of a new language. Nay, it is independent of language, it is a thinking in *form* instead of in words.

It is not thought necessary, in a book meant for teachers mainly, to enter into details about the drawing instruments and materials. It may not be out of place, however, seeing that some Education Authorities appear to regard cheapness as the chief qualification in their purchases of drawing materials, to emphasise the fact that good work cannot be done without good appliances. For satisfactory drawing it is essential to have good paper, good pencils and rubbers, and reliable rulers, set squares and compasses. If cheapness must be considered, then let the restriction be in the quantity of the material rather than the quality.

SOLID GEOMETRY

ORTHOGRAPHIC PROJECTION

Solid, or as it is sometimes termed descriptive, geometry has for its object the correct representation of solid objects—objects of three dimensions, length, width and thickness—on a flat surface. One method of doing this is shown in Fig. 1, which gives a sketch of a simple rectangular block of wood and the method of depicting it, termed orthographic or right line projection, by the use of two surfaces or planes, the one vertical and the other horizontal.

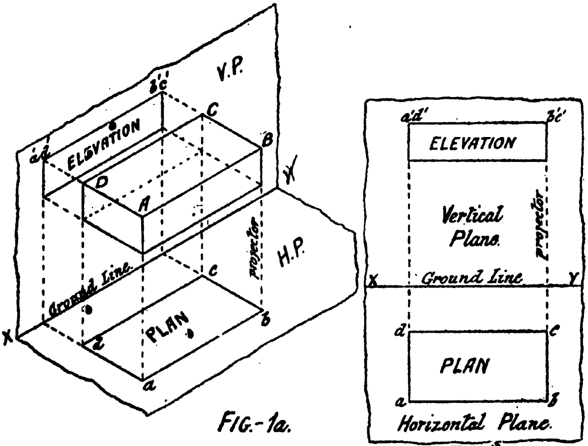


FIG.-1a. FIG.-1b.

Fig. 1.

These two planes are well represented by the wall and the floor of an ordinary room, the line where the floor and wall meet being the ground line, usually indicated by the letters X and Y as shown, and consequently termed the XY line.

To obtain the drawings of the object as in Fig. 1*a*, lines perpendicular to the planes are supposed to pass through points on the object. These lines are termed *projectors*, and the points where they meet the planes are the *projections* of the points on the object through which they pass. The projection on the horizontal plan (H.P.) is known as the *plan*, that on the vertical plane (V.P.) as the *elevation*.

Capital letters are used to denote points on the actual object (A, B, C, etc.), on the plan these points are lettered in small italics (*a*, *b*, *c*, etc.), and in the elevation by the same letters with dashes (*a*′, *b*′, *c*′, etc.). Thus point A denotes an actual point on the object; its plan being marked by *a*; its elevation by *a*′.

It will be noticed that the plan of point A is also plan of point below A, and thus it will be seen that the plans of all points falling on the same projector coincide.

In this case the plan *a*, *b*, *c*, *d* is the projection of both the top and the bottom surfaces of the block ABC, etc; it is usual in such cases to consider the plan as being that of the top surface. In the case of elevations the projection is taken to be that of the surface presented to the observer.

If a piece of paper is folded so as to make a model of the horizontal and vertical planes as in Fig. 1*a*, and the plan and elevation of an object be made upon the paper so folded, when the paper is flattened out again the drawings will appear as in Fig. 1*b*.

By an observation of both drawings it will be seen that the distance that any point stands above the H.P.

(Fig. 1*a*) is shown by the distance the elevation of that point is above XY in Fig. 1*b*. Also the distance any point stands in front of the vertical plane is shown by the distance the plan of that point stands in front of the V.P.

The beginner should make a model of Fig. 1, and study it in connection with what has already been written before proceeding farther. Such study will teach him that the geometrical conceptions and definitions of plan and elevation may fitly be allowed to grow slowly, and by practice with models and drawings, out of " top view " and " front view."

Torn surfaces have been represented in Fig. 1 in order that the student may from the beginning think of the planes of projection as unlimited in extent. The reason why two drawings are needed to define an object by this method is obvious when it is seen that only two dimensions are shown on each. In this case the plan gives length and width only, so that the elevation is necessary to define the thickness. Or, put in another way, the extension of the object right to left is shown in both views, extension back to front in the *plan*, and up and down extension in the *elevation*.

Many objects have edges which are parallel to one plane only, as is the case with the top edge AB of the model shown in Fig. 2.

By looking at the sketch Fig. 2*a* it will be seen that the plan (*ab*) of the line AB is *shorter* than the line itself, while the elevation gives the real length. This shows that the projection of a line upon a plane, by this method of projection, is only equal to the true length of the line when the plane and line are parallel to each other.

It will also be seen that if we reproduce the true shape of the figure A*a* B*b* we shall determine the inclination of AB.

This is shown in Fig. 2*b*, where *a*A *b*B are set off at right angles to the plan and made equal in length to the heights of *a′* and *b′* respectively above XY. By joining A to B we obtain not only the real length of the line but the angle AB makes with H.P. This method of determining the true length of an oblique line and its inclination to H.P. can be used for any straight line no matter what its position in space.

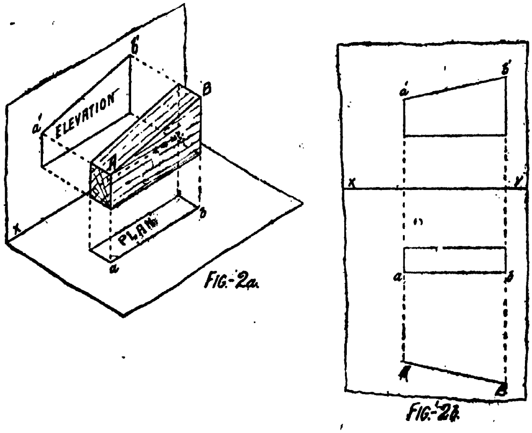


Fig. 2.

In Fig. 3 the line AB is oblique to both planes and the manner of throwing down the projectors is shown in Fig. 3*a*. When shown in plan and elevation it simply comes to setting out two projectors at right angles to the plan and marking off the length of each as given in the elevation. By joining these the real length of the line and its inclination to H.P. are obtained as at AB (Fig. 3*b*).

End Elevations.—Some objects, such as that shown in Fig. 4, are of such a shape that it is necessary to have an additional projection in order that the shape of the object may be clearly comprehended. By placing another vertical plane, as shown in Fig. 4*a*, a projection

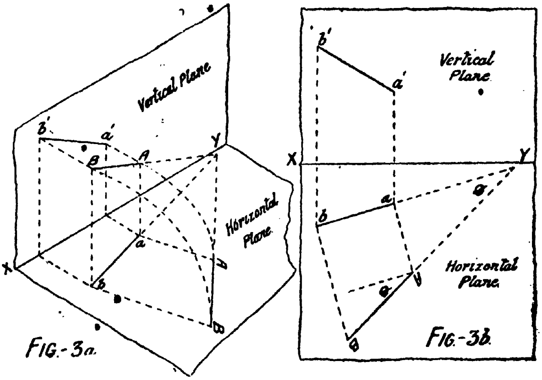


Fig. 3.

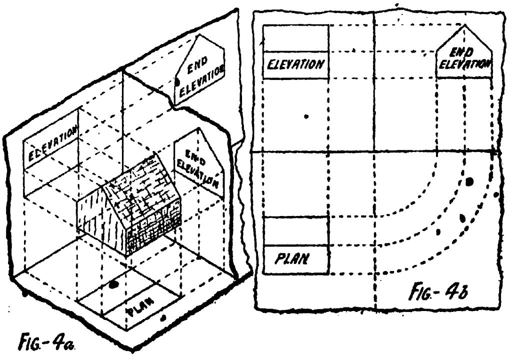


Fig. 4.

can be made upon it showing the appearance of the model when viewed in the direction of the ridge. By cutting and folding the paper, as shown in Fig. 4*b*, a model of the three planes required can be easily and quickly made. If it were necessary to show the other end in a similar manner, the new vertical plane would be placed at the opposite end. The method of projecting an end elevation from plan and side elevation is shown in Fig. 4*b*, and is easily understood from the paper model suggested.

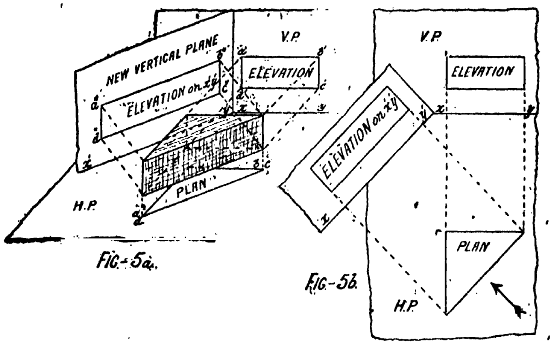


FIG. 5a.
FIG. 5b.

Fig. 5.

Change of Ground Line.—When a solid is not rectangular it often presents surfaces which it is desirable should be represented to their correct size and shape, and which when projected upon the planes already described are not so shown. In Fig. 5, the true shape of the surface ABCD is not shown on the two planes already dealt with. It is necessary, therefore, to introduce a new V.P. in a position parallel to the surface of which the true shape is desired. In Fig. 5, such a V.P. is shown and the direction in which the object has to be viewed indicated by an arrow. When the new V.P. which stands on the ground line X'Y' is thrown down or *rebatted* into the plane of the paper it has the appearance shown in Fig. 5*b*.

To obtain the new elevation *a″b″c″d″* draw projectors from the plan at right angles to X′Y′, making the heights equal to those in original elevation.

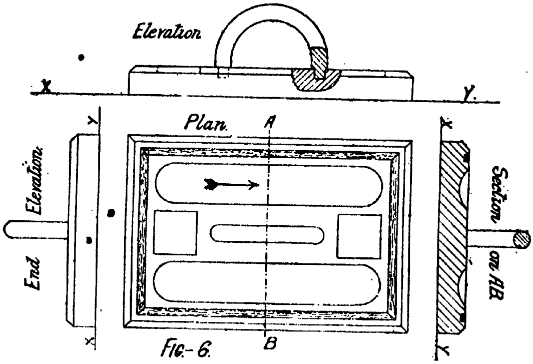


FIG-6.

Sections.—To show the detail of some part of the construction that does not appear from the outside view, two methods may be adopted, (*a*) the detail may be drawn in dotted lines upon one, or both, of the projections, or (*b*) the model may be assumed to be cut through so as to expose the necessary detail (Fig. 6).

The plan and elevations of an inkstand with an inlaid border are shown, and the first method of determining the depths of the inlay and sunk part is shown on
the front elevation, where these detai
dotted lines. The second method is to
model is cut by a vertical plane (such
sented by a saw when cutting " square
the half to the left of the section
remaining portion viewed in the direc

The view so made is termed a section and is shown in Fig. 6, to the right of the plan. It will be noticed that certain parts of the model not cut through appear on this section, such as the elevation of the handle. To distinguish that which is actually cut through, lines are ruled across such parts, the remainder of the drawing being left plain.

When only the cut part is shown the drawing is a *section*; when the whole of what may be seen is added the result is termed a *sectional elevation*. Lines to indicate sections need not be ruled too close, about $\frac{1}{16}$ inch to $\frac{1}{8}$ inch apart being quite close enough. It is customary to section line separate pieces in different directions so as to show up the construction in a clearer manner.

ISOMETRIC PROJECTION

To the untrained eye plan and elevation are not always readily intelligible, so some method of representing the object pictorially is called into service. There are several methods of doing this, the one in most general requisition being known as *Isometric* projection, of which Fig. 7 is an example, showing a cube. This method is best suited for representing rectangular solids and consists in arranging the solid so that one corner, where three edges mutually perpendicular to one another meet, stands in such a manner that each of the edges, meeting at the corner, is equally inclined to the plane of projection. As these edges are inclined to the plane of projection their true length is not shown on the drawing.

To take the example in Fig. 7, the lines *ad*, *ab*, etc., do not give the true length of the edges of the cube, but being equally inclined they are all shortened in the same proportion. The diagonal DB of the face ABCD *is* parallel to the plane of projection and so *db* is the true length of this diagonal. If a square is constructed about this diagonal by use of the 45° set square, the true length of the edges of the cube will be determined, as shown by half the completed square *dCb* (Fig. 7).

Isometric Scale.—The scale by which the isometric

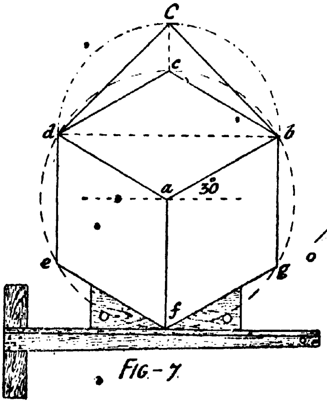


FIG.-7

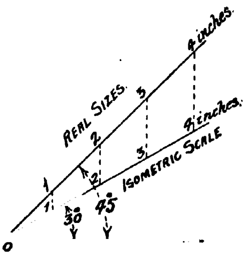


FIG.-8.

projection will have to be measured is therefore easily obtained, as shown in Fig. 8, by drawing a line O4 with the 45° set square and another line O4 with the 30° set square, marking a scale of real inches along the top line and projecting corresponding points on to the line below, figuring the scale as shown.

Owing to the peculiar method of placing the object for projection, all dimensions have to be measured along directions parallel to *ad*, *ab* and *af* (Fig. 7). These are known as the *isometric axes.*

To represent an object with curved surfaces in isometric projection the object must be enclosed in a rectangular solid as shown in Fig. 9, in which a cylinder is shown enclosed by a square prism. To draw the circular end draw lines across the enclosing square *a b c d* (Fig. 9*a*), and corresponding lines across the isometric projection of this square (Fig. 9*b*). Mark off points on these lines 1234, etc., corresponding to those in Fig. 9*a*, which are the intersections of the circle with the lines, and draw the curve through them.

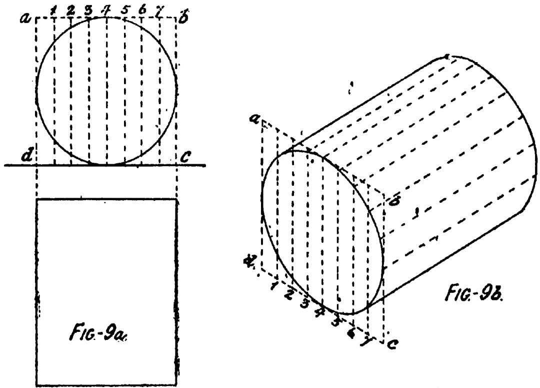


Fig. 9.

Another example of this method of drawing is given in Fig. 10. The drawings Fig. 10*a*, represent a hexagonal pyramid in orthographic projection, while Fig. 10*b* represents the isometric projection of this solid.

To obtain the height of the point *a* above the base in Fig. 10*b* find the centre of the base (*b*) and draw a vertical line making *ab* (Fig. 10*b*) equal to *a′ b′* (Fig. 10*a*). By joining this point to each corner of the base the drawing will be completed.

As the three square faces meeting at the point *a*, Fig. 7, are all equally inclined, the three angles meeting at that point are each 120° in the drawing. The lines *ab*, *ad*, and all others parallel to the isometric axes, except the vertical one, can be drawn with a 30° set square as shown in Fig. 7.

In practice the isometric scale is usually dispensed

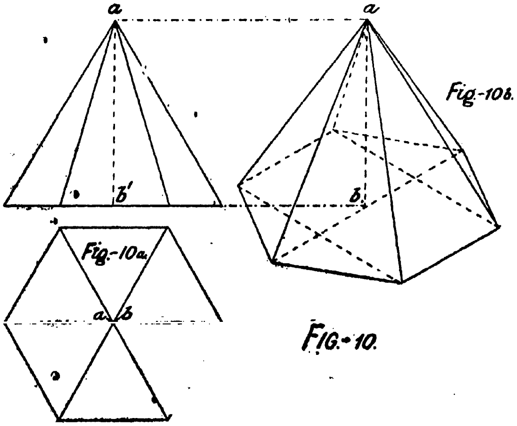


FIG. 10.

with, and the drawing measured with the ordinary rule along the axes. The drawing so obtained is the same shape as when drawn to the isometric scale but larger in the proportion of $\sqrt{3}$ to $\sqrt{2}$. Such drawings are termed *conventional* isometric projections; the inconvenience of using a scale is avoided. The somewhat advanced and complicated theory of isometric projection should not be put before any but the very advanced pupils. It is as well to remember that it is not absolutely necessary to know the underlying principles of everything. We can make good use of a watch without understanding its works.

The method of making conventional isometric drawings is easily taught because of its pictorial attractiveness, and for all practical purposes it is quite sufficient to be able to draw the object by use of this method without understanding the underlying theory, though if the, pupils have worked through the elementary principles of projection in a manner similar to that given in the foregoing pages but more suited, by amplification, modification, and greater detail, to their intelligence, the comprehension of the theory of isometric projection will not be found too difficult for them to master. Still we insist that for any but the more advanced the theory of this method of projection should not be put before the pupil, and there is some real advantage gained in the facility with which set squares are manipulated and in the possession of another and convenient method of representing what is wanted.

For blackboard sketching, isometric sketches are extremely useful, as anyone knows who has to deal with pupils only slightly acquainted with the art of projection.

OBLIQUE PROJECTION

What is termed an *oblique projection* is shown in Fig. 11. The difference between this and an isometric projection is that one face of the object is drawn to the *true* shape. The parallel slanting lines giving the appearance of solidity to the picture can be drawn at any angle and measured either to full size or to any scale according to which gives the truest representation of the actual appearance of the object.

For the pupils using this method no theory is necessary; all that has to be done is to draw one correct projection of the object and by use of the set square draw lines at any angle, preferably 45°, and mark off the thickness of the object. The easiest scale by which to measure the sloping lines to show the thickness is naturally that of full size, but a better picture is obtained by using a scale of one-half full size as shown in Fig. 12, which gives the drawing of a cube by this method.

To understand the theory of this method of projection it is only necessary to make a small paper model and

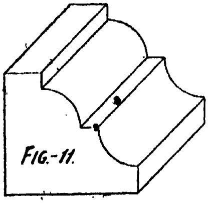


FIG.-11.

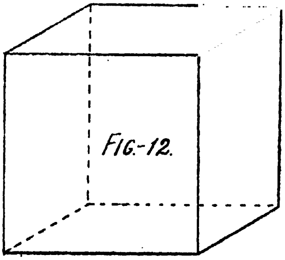


FIG.-12.

experiment with it as will be described. The new feature is that the *projectors are oblique to the planes of projection* and may make any angle with them. In Fig. 13 a line AB is shown lying on H.P. and projected on to V.P. by projectors at 45° to V.P. giving the elevation of AB at a' b'. Cut the paper along the lines indicated and make AB the hinge about which the cut out piece is to swing. Next fold the V.P. till it stands at right angles to H.P. It will then be seen by swinging the projectors, which in every position still remain at 45° to V.P., that a^2 b^2, a^3 b^3, etc., are some of the many possible projections of AB. Consequently a line like AB perpendicular to the V.P. can have by this method an elevation making any angle with XY that one chooses.

Again, the example in Fig. 13 was worked with projectors at 45° to V.P. and gives, as can easily be seen, a length to the elevations a' b', etc., equal to the length of the line AB. Other angles might have been chosen, such as those shown in Fig. 14.

The projectors at 30° make the elevation longer and those at 60° make it shorter than the line. As any

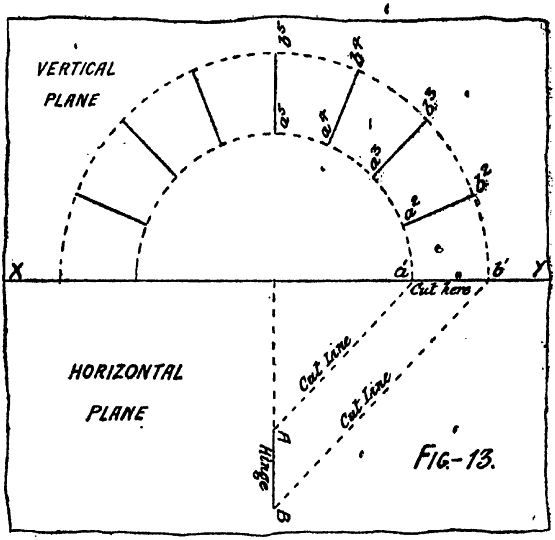


FIG-13.

other angle might be used the projection of these lines by this method can be of any length. It was proved above that these same lines could be drawn at any angle and correctly represent the original, and now it has been shown they may be of any length also and still be the correct projection of the same lines.

Therefore the sloping lines may be drawn at any convenient angle and measured to any scale in oblique projection.

The more usual plan is to draw the slanting edges to the real length. It will be admitted, we think, that this method almost always distorts the object represented; and as it has also been shown that the oblique projectors

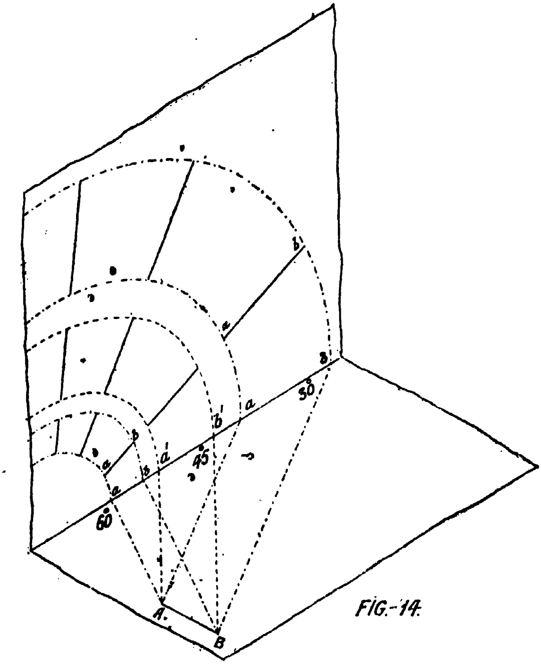


FIG.-14.

may with equal correctness be drawn at *any* angle, and may project to either real length, or shorter, or longer than the real length, there seems to be a good reason for exercising discretion in the scale adopted for these lines when a better pictorial projection may thus be obtained. In fact, the question may naturally arise—Is the method of oblique projection, with its widely varying results, all equally demonstrably correct, really a scientific one? Without hazarding an answer to this it may be said, that this method of representation is undoubtedly best suited to rapid hand or blackboard sketching, where

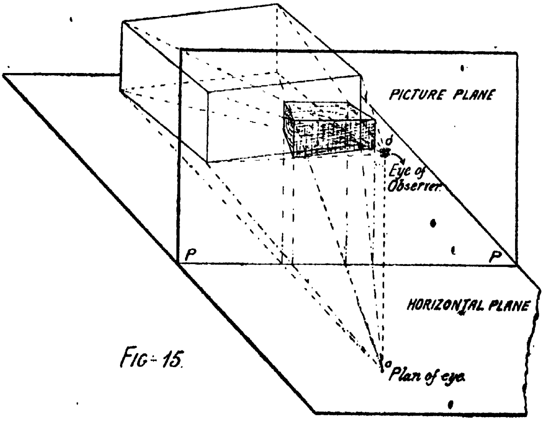


FIG-15.

it has some distinct advantages over isometric projection as a rule.

The remarks that were made upon teaching the theory of isometric projection apply with even more force here. Again, this system is of most value in allowing a quick explanatory picture to be made of some badly understood detail of construction. The method is specially valuable as showing the solid appearance of mouldings by the addition of the sloping lines to any section that may be given.

PERSPECTIVE OR RADIAL PROJECTION

What is known as *perspective* or *radial projection* is obtained by supposing all the projectors to pass from the model to a single point representing the observer's eye and to be cut by a picture plane. The picture is formed as shown in Fig. 15, and gives a correct representation of how the model actually *appears* to the eye.

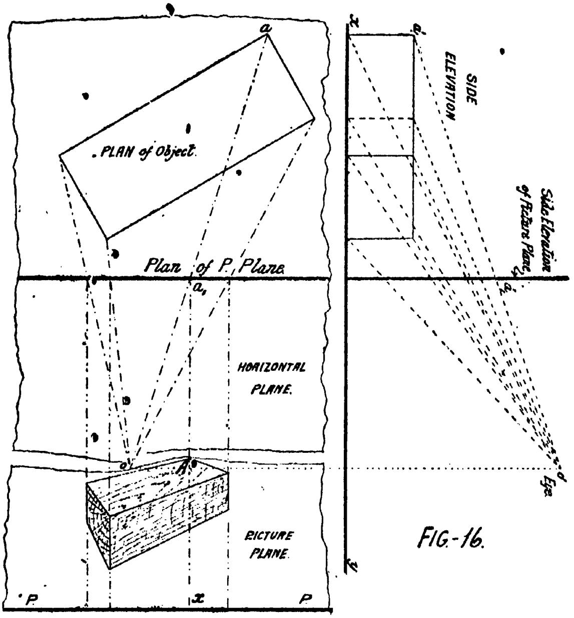


FIG-16.

The geometrical method of obtaining the perspective of a simple rectangular block is shown in Fig. 16. The plan and end elevations of block and picture plane are drawn, as shown, together with the plan and elevation of point of observation, to which all projectors radiate. A front elevation of picture plane is drawn beneath its plan at any convenient distance below it. To draw the perspective of any point a on this picture plane join the point in plan and elevation to the point of observation o. Then $a_,$ is the plan of the intersection, and a' the elevation of the intersection of ao with the picture plane. From $a_,$ drop $a_,x$ at right angles to picture plane and measure off the height Ax, equal to $a'_,x'$, from some convenient base line. Then A is perspective of point a, and in a similar way the perspective of every other point may be found. It is well to notice that in perspective drawings all vertical lines on the object are represented by vertical lines in the drawing.

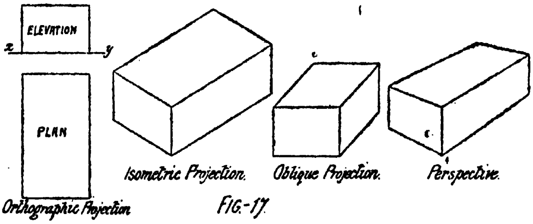


FIG.-17

As the projection of lines of equal length vary according to their position and distance from the picture plane, no scale can be applied to this kind of drawing. Consequently, it has no value for working drawings beyond its occasional use as a method by which the actual appearance of the object can be correctly shown. For this purpose it stands alone when compared with any other method.

Comparison of Methods of Projections.—In order that the various methods of projection can be easily compared the same model has been drawn by each in Fig. 17.

For a teacher it is necessary to have some degree of facility in the use of each of these methods, so that his verbal explanations may be emphasised and rendered clearer by the use of suitable drawings appealing to the eye.

A quickly drawn sketch often adds an interest out of all proportion to the trouble involved, and gives the visual as well as the auditory type of pupil a chance to assimilate the information imparted in the manner most suitable for him.

REFERENCES

" Practical Plane and Solid Geometry," by Harrison (Macmillan, 2s. 6d.) ; " First Stage Practical Plane and Solid Geometry," by Burn (University Tutorial Press, 2s.) ; " Practical Plane and Solid Geometry," by Angel (Collins & Son, Vol. I. text 6s. ; Vol. II. plates 4s.) ; " Oblique and Isometric Projection," by John Watson (Edward Arnold, 3s. 6d.).

CHAPTER XII

BENCHWORK

THE BUILDING UP OF A SCHEME

"Children do most naturally delight in things, and are most capable of learning them; and how they love toys, making ships with paper, setting even nutshells a swimming, handling tools of workmen as soon as they turn their backs, and trying to work themselves."—SIR W. PETTY, 1623-66.

"One disastrous tendency has always shown itself in the schoolroom—the tendency to sever all connection between studies in the schoolroom and the life outside."—R. H. QUICK.

"It is the aim of the Manual Training courses to give a greater breadth of interest to school work; to prepare the child to understand human civilisation on its mechanical or constructive side; to develop constructive ability; to train in methodical thought and action; and to inculcate habits of industry and a love for law and order."—*Ethical Culture School, New York.*

"In handwork each child must bend himself to the task, and his attention or inattention, his success or failure, registers itself in an unmistakable form."—H. THISELTON MARK.

"If sloyd exercises have not improved his general physical condition, increased his power of clear thinking, aroused and stimulated right feeling, strengthened his will, trained the eye, developed judgment, a love of excellence, contempt for shams of all kinds, and implanted a wholesome self-respect, then it has not accomplished its object."—GUSTAF LARSSON.

"If, instead of keeping a child at his books, I keep him busy in a workshop, his hands work to the advantage of his intellect; he becomes a philosopher while he thinks he is becoming simply an artisan."—J. J. ROUSSEAU, 1712-78.

"Not many things of this world give me more pleasure than to watch a cunning craftsman as he smooths timber, and fits the pieces together, and makes of them something that shall serve the needs of men. Is it not, in some sort, to imitate the great Artificer? Would that our country had more makers and fewer who live but to destroy."—The Abbot in GEO. GISSING'S "Veranilda."

THE models illustrated in these pages are put forward as a working basis from which teachers may evolve schemes to suit their varying requirements.

We have elsewhere spoken against stereotyped courses of models, and every practical teacher knows how difficult it is to pursue with ever renewed interest and enthusiasm the presentation of courses of work which remain permanent in spite of the diverse needs of the pupils and the personality of the teacher. The teacher should build up a course for himself from his practical experience, keeping a sketch-book containing the records of his failures as well as his successes for the purpose. It is hoped that the schemes submitted will be a helpful guide to inexperienced teachers and prove suggestive even to the more experienced.

It is desirable that as far as possible the work should be of the nature of models which appeal to and hold the interests of the scholars, rather than purely manipulative exercises. To this end toys and useful objects have been freely introduced. At the same time it must be borne in mind that in the early stages of the work mere exercises have a deep interest for the pupils on account of the novelty of the work.

The sequence of the various tool manipulations cannot be laid down with that definite precision some schemes seem to suggest. For instance, the spokeshave is a tool usually relegated to a late position, while in practice it proves far less difficult, when suitably introduced, than is generally supposed. Sawing across the fibres with the tenon saw, however, should precede sawing along the fibres, as the latter is undoubtedly more difficult. All this is a matter of experience, and each teacher must judge for himself after putting his ideas to careful experiment.

Some easy preliminary work, to be executed in prepared wood, is shown that may be used where it is thought desirable, as for example with younger boys or mentally defective children. Two alternative schemes are presented after this preliminary work. Either of these may be adopted as given, or a choice may be made from both schemes. For the less skilful it may be desirable to lengthen the initiatory steps; this may be done by supplementing one scheme from the other. Thus a lad who does badly with No. 8 may proceed to No. 9*a* instead of No. 9.

The drawings of the more advanced models which follow are given somewhat in their order of difficulty. From these a selection may be made. Whenever a number of equally suitable models are available the child may be allowed to make his own selection. The pupils should also be encouraged to design models, or parts of them, for themselves. Suitable training in this is what may be termed the "blank model" method, where only over-all measurements are given leaving the design and detail for the pupils to work out.

In addition to the working drawings, several pages of sketches are given which it was not thought necessary to show in detail. These may serve as suggestions for models if it is desired to add to those shown. The few benchwork notes in this chapter are drawn up with the intention of helping the beginner in commencing his scheme and to elucidate some less obvious points in some of the more advanced models. Beyond this it is not thought necessary to go, as practical skill is best acquired through personal example and many books already exist that deal with the methods of tool manipulation at great length. These are mentioned at the end of Chapter VI.

It is not the practice in this country, as a rule, to finish the models by polishing or varnishing them ; but there is no reason why many of the advanced pieces of work should not receive a finish of some kind. Oak, satin-walnut, and walnut, etc., may be oiled a few times with linseed oil, preferably applied hot, and well rubbed with a soft cloth, or beeswax and turpentine dissolved into a thick paste may be rubbed on. Both of these methods give a dull polish and little skill is needed to carry them out. Shellac varnish, made by dissolving shellac in methylated spirits, is a quick-drying varnish, and if carefully laid on with a fine brush, and glass-papered with very fine, worn paper between the coats, gives a good finish. The shellac gives a yellowish tint to the work unless clear white shellac is used.

Copal varnish can be used instead of the shellac, but this has the disadvantage of taking twenty-four hours or more to dry, so that a room free from dust is really needed to carry this out properly. The pores of the wood may first be closed with a paste " filler." Glass-paper after each coat and then rub down with pumice powder made into a paste with either oil or water and applied on a piece of felt cloth. Finished off with a finer rubber, rotten stone, this gives a beautifully glossy surface. It goes without saying, of course, that a good finish cannot be obtained unless the toolwork has been carefully done beforehand.

Basswood and other soft woods may be stained by means of dry colour stains, such as house painters use, mixed with boiled linseed oil and turpentine. Two colours may be mixed dry to obtain the desired shade, adding the oil and turpentine afterwards. Apply with a piece of cloth, and when dry, polish or varnish as above.

A solution of bichromate of potash turns oak a reddish-brown. It is yellowish when first dry, but rubbed with an oiled cloth turns reddish in colour. The same stain will turn light mahogany to a rich red tint, adding considerably to its appearance.

When using water stains it is well to wet the wood first in order to raise the grain. When dry, glass-paper this down again, and the water stain will then not raise it as it would do otherwise.

Some of the models look well enamelled. A coat of thin glue size put on first economises the enamel by filling up the pores beforehand.

The method of carrying out the decoration of some of the models is described later on. Reference may be made to this by the reader.

LIST OF ILLUSTRATIONS OF MODELS

PRELIMINARY STRIPWORK COURSE

1. Square
2. Picture Post Card Frame
3. Cigarette Card Frame
4. Signal
5. Calendar Stand
6. Truck
7. Pot Stand
8. Key Rack
9. Ladder
10. Trolley
11. Photo Stand
12. Table
13. Envelope Stand
14. Porter's Truck

LIST OF MODELS

Scheme A	*Scheme B*
Fig.	Fig.
1*Building Blocks	1*a**Building Blocks
2*Match-box Bracket	2*a* Cleats
3*Line Winder	3*a**String Winder

Scheme A

Fig.
4 Grooving
5 Simple Inkstand
6 Marble Board
7 Toy Stool
8 Match-box Stand
9*Toy Armchair
10 Small Bracket
11 Chamfered Inkstand
12*Noughts and Crosses Board
13 {Towel-rail and Supports
14
15*Table Mat
16 Bread Board
17 Letter Rack
18 Flower Pot Stand

Scheme B

Fig.
4*a**Pot Stand
5*a* Egg Stand
6*a* Luggage Labels
7*a* Simple Inkstand
8*a* Marble Board
9*a* Match-box Rack
10*a* Pen Stand
11*a* Garden Stick
12*a**18 in. Rule
13*a* Soap Rack
14*a* Paper File
15*a* Small Bracket
16*a**Tie Rack (decorated)
17*a**Scissors Rack (see Fig. 19*a*)
18*a**Palette Bracket (see Fig. 19*a*)
19*a**Suggested decoration for 17*a* and 18*a*

More Advanced Models

Fig.
19 "Cradle" or Fillet Board
20 Key Rack
21 Pen Rest
22*Ink and Letter Stand (decorated)
23 Chamfered Shield
24 Egg Stand
25 Clothes Line Winder
26 Racket
27 Garden Dibble

Fig.
28 Ruler for Model Drawing
29 Elliptical Inkstand
30 Puzzle Money Box
31 Date Case
32 Photograph Frame
33 Photograph Frame
34*Simple Weighing Machine
35 Oxford Picture Frame
36 Coat Hanger
37*2 ft. Rule

Fig.
38 Parquetry Mat
39 Inlaid Mat
40 Tent Peg
41*Blotter (decorated)
42 Corner Bracket
43 Shelves for Boot Brushes
44 Paper Knife
45 Drying Rack for Negatives
46 Toy Stool
47 A Shield
48 Book Rest
49 Hat Rack
50 Pipe Rack
51 Double Inkstand
52 Wall Bracket
53 Bread Board
54 Penholder
55 Book Trough
56*"Steelyard" Balance
57 Ivy Leaf Key Rack
58*Pantagraph
59 Pantagraph
60 Details of Tilt Hammer
61 Model of Tilt Hammer
62 Trefoil Flower Pot Stand
63*Book Support (decorated)
64 Knife Box
65 Envelope Openers
66 Trinket Tray
67 Crumb Tray and Scraper

Fig.
68*Dovetailed Box (decorated)
69 Writing Desk
70*Letter Balance
71 Photo Bracket
72 Foot Stool
73 Photo Frame
74*Rectangular Parquetry Mat
75*Square Parquetry Mat
76*Advanced Parquetry Mat
77 Hexagonal Inlaid Stand
78 Sliding Book Rack
79 Hexagonal Plant Stand
80 Circular Plant Stand
81*Chess Board
82 Large Photo Shield
83 Mirror Frame
84 Fire Screen
85 Drawing Board, Tee Square, and Set Squares
86 Various Woodwork Joints
87 Simple Tools and Appliances
88 School Apparatus
89 School Apparatus
90 Hobbies
91 Some Dolls' Furniture
92 Boys' Toys

* These Models are dealt with in the Notes on Models below.

NOTES ON THE PRELIMINARY STRIPWORK

Tools required.—20 small dovetail saws; 20 small hammers; 20 small try squares; 20 wood rules; 10 fine bradawls; 10 small punches; 2 pairs of pincers; liquid glue; ½″ steel brads; ⅝″ and 1¼″ brass pins. No set squares are needed if the necessary drawing is done in books ruled in ½″ squares. The timber most suitable is satin-walnut of the following sizes: 3½″ × ¼″; ½″ × ½″ and ½″ × ¼″.

The course.—The simple nature of this preliminary stripwork, together with its small equipment and absence of keen edged tools (marking out being done with a pencil), makes it particularly suited for younger and mentally weak boys. It could also be worked in the ordinary classroom, the desks being fitted with a movable top and a sawing board.

In this course, as in others, the pupils make more progress when they are allowed to draw from actual models. With a particularly weak class of mentally deficient boys it was found that they soon acquired a reasonable degree of accuracy when they saw that unless the work was somewhere near the mark the picture post card, for example, would not fit. When the model is too complicated to be drawn in plan and elevation as in the ordinary work, the parts may be drawn separately and afterwards assembled. The lads can actually lay the pieces as they saw them off over their drawings and nail them together in position. It will be noticed that the sizes are given in ½″ and ¼″, but ⅛″ and 1/16″ may easily be introduced with sharp boys by modifying some of the sizes. The wheels are cut with a 1¼″ bit having the horizontal cutter filed away.

Such a course as the one shown can be profitably prolonged to take up six months of two hours per week, and the introduction of additional sizes and kinds of material would greatly enlarge the scope of this preliminary scheme, which is given as an example of what can be done at an early stage with very simple materials.

NOTES ON THE MODELS

COMMENCING THE BENCHWORK

For young boys it is strongly recommended that a brief course of stripwork be worked through before commencing the later scheme. The timber for the stripwork should be machine-planed, and the first few models in the later course may also be carried out in ready prepared wood.

In any case it is desirable that the first model should be of machine-planed wood.

MODEL I.—BUILDING BLOCKS (Figs. 1, 1*a*)

Two methods of teaching this model are given.

FIRST METHOD.—Commence with the woodwork. Show how to mark off an end with the try square and marking knife, taking care to note that these tools are properly held. Let the pupils cut off the waste end, after they have been instructed in the difference between sawing on the line and on the waste. If the first attempt is not satisfactory allow them to try again. Then mark out all the blocks, allowing the width of a saw-cut between the ends. Insist upon each block being tested with the square; this gives the muscles of the hand and arm the necessary brief interval of rest to avoid fatigue.

The drawing may now be made.

Supply to each pupil a sheet of paper for sketching on. Let them fold it as in sketch (Fig. 1), calling the two surfaces so formed "*wall*" and "*floor*." Only a few very simple directions should be given as to the drawings required and the pupils then left to make their freehand attempts. Flatten out the sketch papers and teach the pupils to make similar drawings by use of drawing instruments in drawing books. Nothing is to be said at this stage about co-ordinate planes but the two drawings may be called plan and elevation, and the fold of the paper designated by *xy*, leaving the meaning of these terms to grow upon the pupils by practice in drawing.

SECOND METHOD.—Commence with the drawing. This may be carried out in the manner already explained, a number of ready-made models being substituted for the pupils' own work. *Woodwork.*—Supply each pupil with a piece of wood sufficiently long to make all the blocks plus an inch for waste. Let the pupils mark their own face sides and edges. Teach the holding of the try squares and marking knife. The pupils test end of block, which is probably not square; also it is roughly sawn. Therefore square off a small piece of waste. Mark off length of smallest block. How long is it? How do you know? *We have drawn it.* Then you see the use of drawings. Make a saw-cut and ask if it matters which side of the line we saw. Cut off waste end and test it. Pupils do this and attempt to stand wood upright on sawn end to demonstrate squareness. Cut off the block marked out. With the remaining length of wood, which in many cases will not have a square end, let the pupils attempt to repeat the process in cutting second smallest block without help If they cannot do this demonstrate again. Most boys will mark out and cut the third block correctly. Each block may be fitted on the drawing as soon as it is cut.

MATCH-BOX BRACKET (Fig. 2).—Let the pupils make their own freehand sketches from a piece of wood showing "marking-out," as in Fig. 2, with the waste parts blacked in or otherwise distinguished. An end elevation may be used, the paper being folded along *xy*. Have the finished drawing made in the books, leaving room for front and side elevation of completed model. In starting the woodwork the part sawn out along the grain should be worked first. Have the wood long enough to allow of two attempts at this, if necessary.

The finished model may now be sketched and drawn. When folding the paper for sketch show that two "walls" are necessary this time, as in Fig. 2.

LINE WINDER (Fig. 3).—The outline of this model should be drawn from the given ordinates. In the woodwork the spokeshaving should be completed before the ends are sawn off.

STRING WINDER (Fig. 3*a*) and POT STAND (Fig. 4*a*).—These models may be made either from prepared wood, or the strips may be sawn from wood planed up to ⅞″ thick.

TOY ARMCHAIR (Fig. 9).—May be made 5½″ long as a Toy Couch or Hall Seat.

NOUGHTS AND CROSSES BOARD (Fig. 12).—This model allows "noughts and crosses" to be played without the use of pencil and paper.

18-INCH RULE AND 2-FOOT RULE (Fig. 12*a* and Fig. 37).—The numbering may be done in pencil and then lightly cut in with a fine bradawl to give permanency.

TABLE MAT (Fig. 15).—Use alternate light and dark strips for contrast. Shoot one colour "face down" and the other "face up." Glue the strips together face down.

TIE RACK (Fig. 16*a*). SCISSORS RACK AND PALETTE BRACKET (Figs. 17*a*, 18*a*, 19*a*).—The method of carrying out the decoration of these models, given below, applies also to those in Figs. 22, 41, 63, and 68.

When the models are made of basswood, pine, or yellow deal, it is better to stain the wood before applying the decoration ; in cases where the colour and marking are in themselves a pleasing feature the design may be applied direct. A stain giving a light brown or walnut finish to the soft woods named may be made by dissolving a little permanganate of potash in warm water. See that the solution is weak or too dark a stain will result, and the bristles of the brush will be burned away. Use an old brush in any case to apply the stain, afterwards wiping over the surface with clean shavings or cotton waste. The stain should be light in tint or there will not be enough contrast when the darker design is painted. Ordinary water stains may be used instead of the above, or oil paint diluted with turpentine and wiped off as already described. Good effects may be obtained by combining two colours. Neutral tones of brown, green, or dark red are perhaps the most effective.

When the stain is quite dry the design is marked out. The design may be prepared during the art lesson in class, or the boys be asked to work it out at home in readiness, and so avoid undue inroad into the time set apart for the woodwork lesson. If the design is symmetrical, only one-half need be drawn on paper. This can then be transferred to the wood by means of carbon paper by tracing over the outline with a pencil and then reversing the pattern by turning the paper over, which will have the design marked on the underside from the carbon paper. The illustrations show the kind of mass treatment which is most suitable.

The colour tone for the design should be similar to that of the background, but deeper. For the brown stain burnt umber would be right. Ordinary water colours are used, and the decoration may be all in one colour or two or three colours used. The effect is heightened if a fine line of india ink is drawn round the outline of the pattern. Use a fine camel-hair or sable brush.

After the paint is dry it must be fixed by giving the model several coats of shellac varnish (French polish), using a camel-hair brush and glass-papering each coat when set with very fine well-worn glass-paper. Another good method is to apply wax polish—beeswax and turpentine dissolved in gentle heat, care being taken that the turpentine does not fire. Plenty of elbow grease and a soft cloth will produce a dull gloss which has a very pleasing effect.

SCISSORS RACK (Figs. 17*a* and 19*a*).—For decoration see Fig. 16*a*.

PALETTE BRACKET (Figs 18*a* and 19*a*).—For decoration see Fig. 16*a*.

INK and LETTER STAND (Fig. 22).—For decoration see Fig. 16*a*.

SIMPLE WEIGHING MACHINE (Fig. 34).—This model is an excellent lesson in leverage. The counter-balance may readily be cast in lead. Bore a hole to the required diameter in a piece of wood ½″ thick; make saw-cuts to receive the bent wire or hairpin shown in the diagram; place the wood on a block of iron (such as an iron weight or flat-iron) and pour in the metal. The lead is easily melted by using a small ladle over the gas ring used for heating the glue pot. Saw through the wood on opposite edges when the lead is cold.

Mark the position of the counter-balance on the long arm of the lever when weights of 4 ozs., 5 ozs., etc., are successively suspended on the hook. In order to graduate the machine for weights of 1 oz. to 4 ozs., it is necessary to hang the *counter-balance* on the hook and suspend the weights on the long arm, marking their positions. The weighing machine when marked is then independent of weights.

If ordinary weights are not available leaden weights with wire hooks top and bottom, so as to hang under each other, may be made in the way explained for the counter-balance, and tested on the balance of the physics room. A few lengths of stout wire to weigh 1 oz. each bent into a loop, may be used as weights.

Two-foot Rule (Fig. 37).—See Fig. 12*a*.

Blotter (Fig. 41).—For decoration see Fig. 16*a*.

Steelyard Balance (Fig. 56).—Cast the lead as explained above for the Simple Weighing Machine, first driving two ¾″ brads into the inner edge of the hole, so that they will be embedded in the lead and act as keys. Tap the lead gently with the hammer as soon as it cools in order to make up for any slight contraction of the metal. It will be found that the lead is quite secure and may be chiselled and planed off flush with the wood. All this should be done before any of the wood is cut away. A convenient way of marking is to screw a piece of wood about 10″ long and 1″ square in the vice. Near the top end a smooth nail should be driven in horizontally to serve as a fulcrum. Hang the weights on the hook, 1 oz., 2 ozs., etc., and mark where the fulcrum is when balanced. When the marking is completed a cord may be used as fulcrum when weighing any object.

Pantagraph (Fig. 58).—The drawing shows the right position for enlarging the copy to twice the size (four times area). If the bar which holds the tracer is moved so that A is on A^1 the enlargement is 4 to 1; and when A is screwed at A^2 the proportion is 4 to 3. In both these positions the tracer must be in the other hole. The pivot may be fastened down with drawing pins. Pencil, tracer, and pivot should lie in a straight line, otherwise the copy will be distorted. Of course the position of pencil and tracer must be reversed when a reduction in the size of the copy is desired.

Book Support (Fig. 63).—For holding up the end books of an unfilled shelf. It has the merit of requiring only one joint and is therefore suitable for an early attempt at dovetailing. For decoration see Fig. 16*a*.

Dovetailed Box (Fig. 68).—For decoration see Fig. 16*a*.

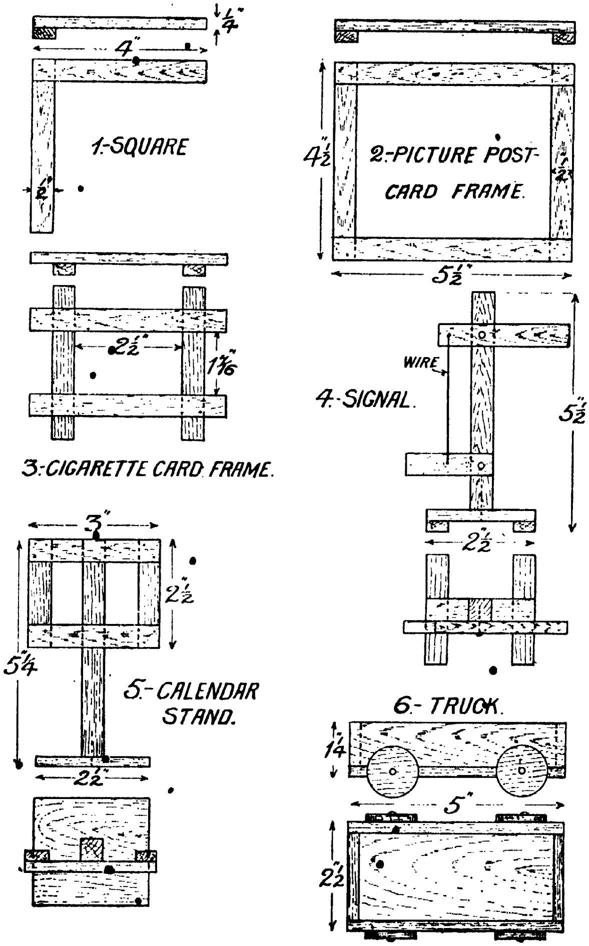
Letter Balance (Fig. 70).—The method of casting the lead is explained above—see Simple Weighing Machine and the Steelyard Balance. The swivel hook may be made out of a brass curtain hook. The thin washers are cut by means of a brace and ½″ bit out of wood $\frac{1}{16}$″ thick. The marking should be done on a level surface with the cam in the position shown. When used afterwards the pointer should be at zero; the cam allows of adjustment in this respect.

Oblong Parquetry Mat (Fig. 74).—The four centre strips may be glued up in 7-inch lengths and afterwards cut through the middle and reversed.

Square Parquetry Mat (Fig. 76).—Glue up the centre star then fill in squares and triangles. The five strips in the border should be glued together before the mitres are cut. The base may have a dovetailed key inserted to keep it true.

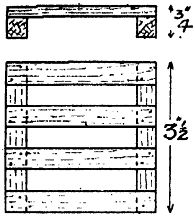
Chess Board (Fig. 81).—The chequers are prepared in strips about 15″ long and after being glued are cut across, thus giving a row of squares. The border is prepared as in previous example.

PRELIMINARY STRIPWORK

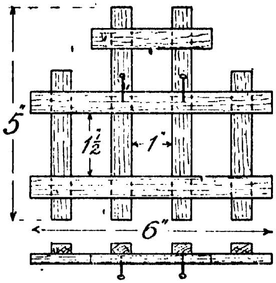


See page 225.

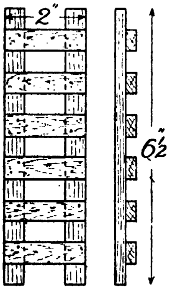
PRELIMINARY STRIPWORK



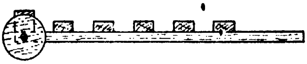
7.- POT STAND



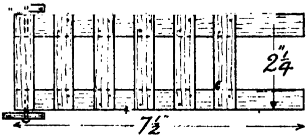
8.- KEY RACK.



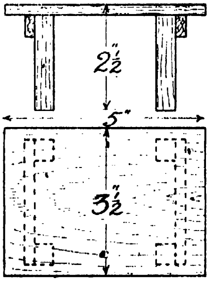
9.- LADDER

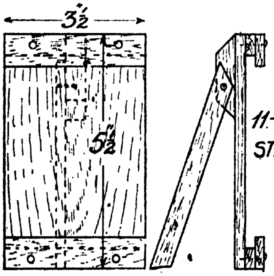


10.- TROLLEY.



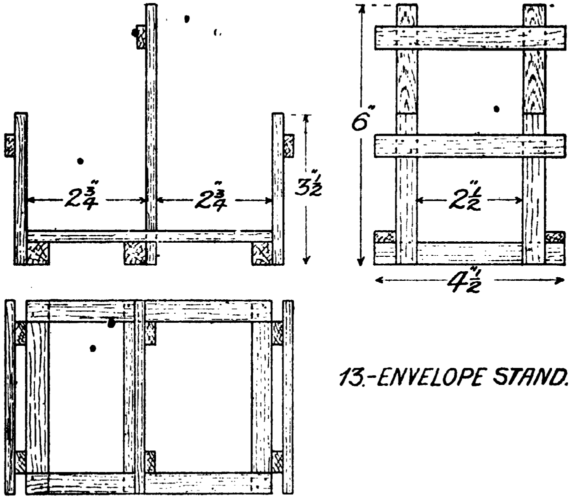
12.- TABLE.



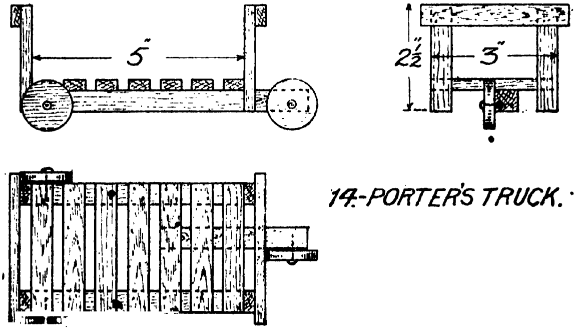


11-PHOTO STAND.

PRELIMINARY STRIPWORK



13.-ENVELOPE STAND.



14.-PORTER'S TRUCK.

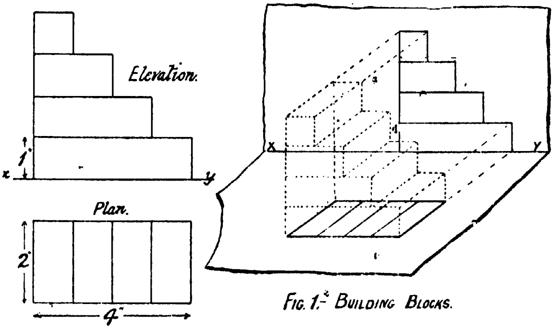


FIG. 1.—BUILDING BLOCKS.

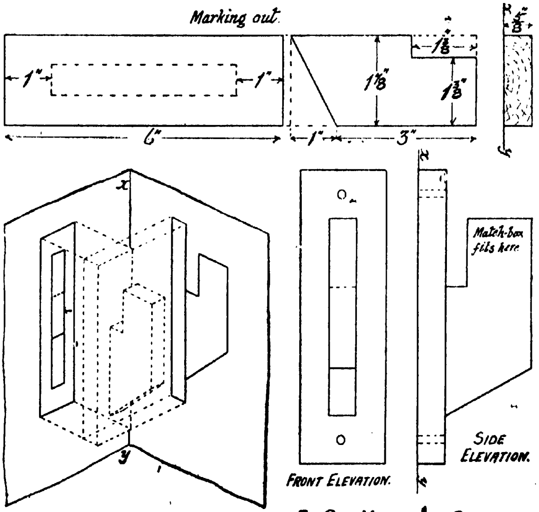


FIG. 2.—MATCH-BOX BRACKET.

See pages 226, 227.

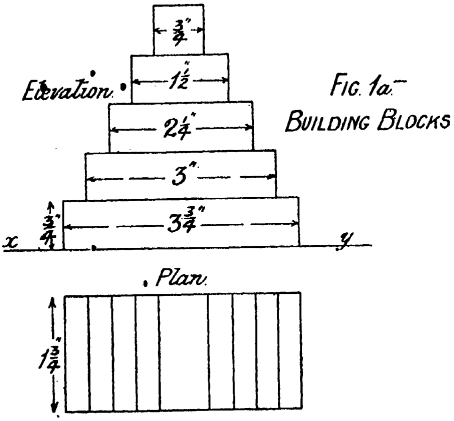


Fig. 1a.— Building Blocks

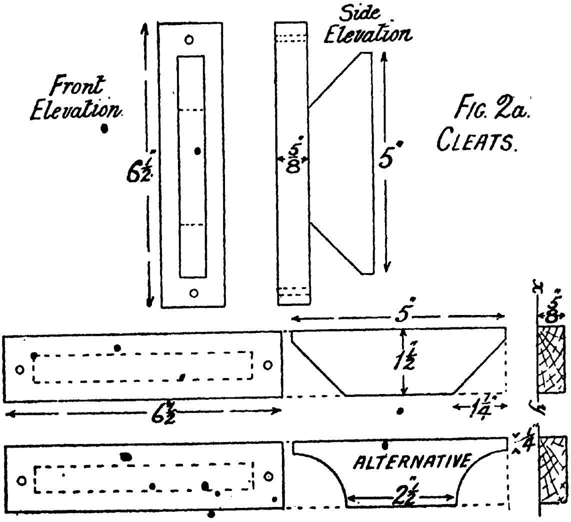


Fig. 2a. Cleats.

Fig. 1*a*. See page 226.

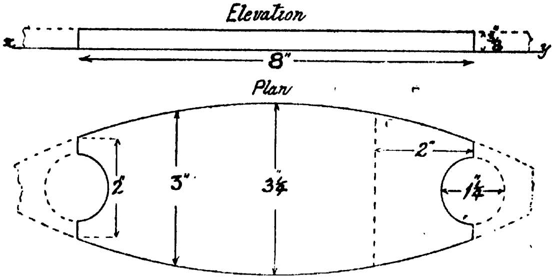


FIG. 3.-LINE WINDER.

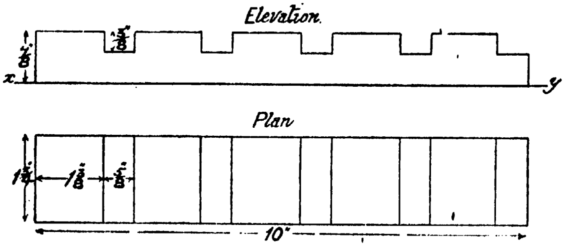


FIG. 4-GROOVING.

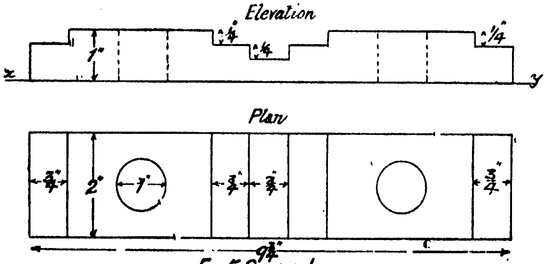


FIG. 5-SIMPLE INKSTAND.

Fig. 3. See page 228.

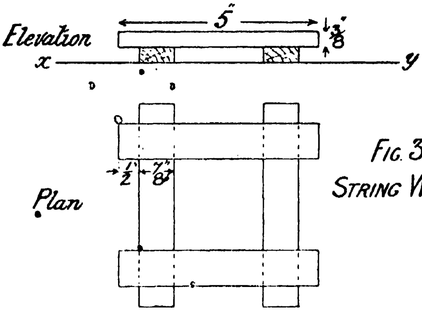


FIG. 3a — STRING WINDER.

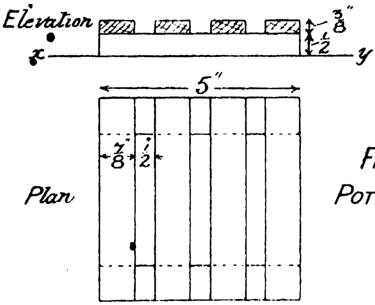


FIG 4a — POT STAND.

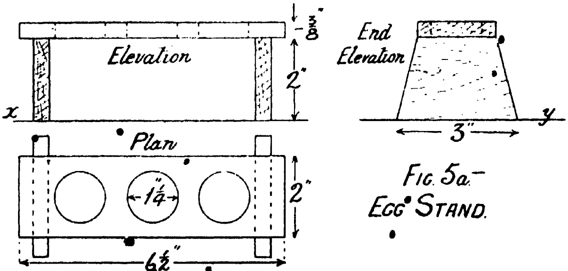


FIG. 5a — EGG STAND.

Figs. 3a and 4a. See page 228.

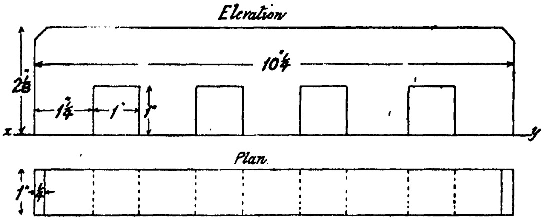


FIG. 6- MARBLE BOARD

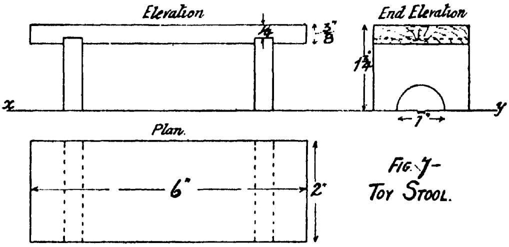


FIG. 7- TOY STOOL.

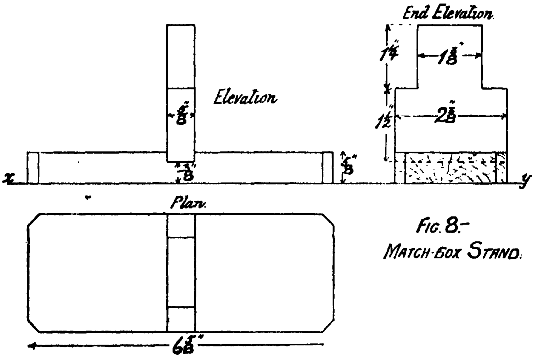


FIG. 8.- MATCH-BOX STAND.

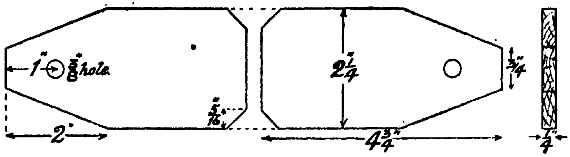


FIG. 6a.—LUGGAGE LABELS.

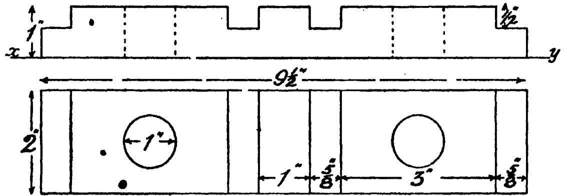


FIG. 7a.—SIMPLE INKSTAND

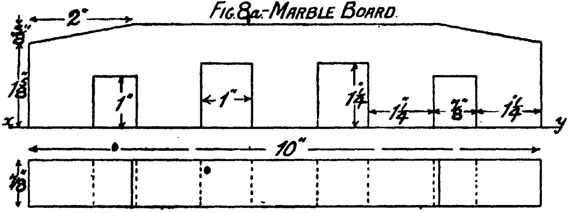


FIG. 8a.—MARBLE BOARD.

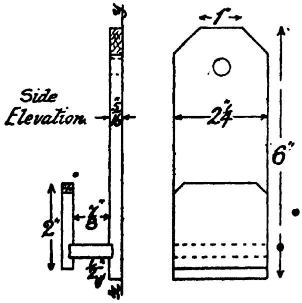


FIG. 9a.—MATCH-BOX RACK

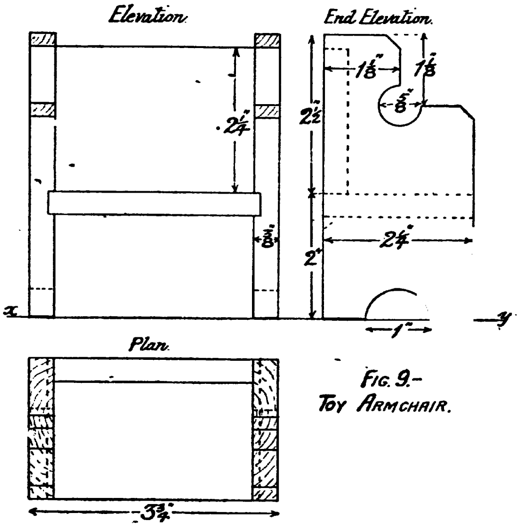


FIG. 9.–
TOY ARMCHAIR.

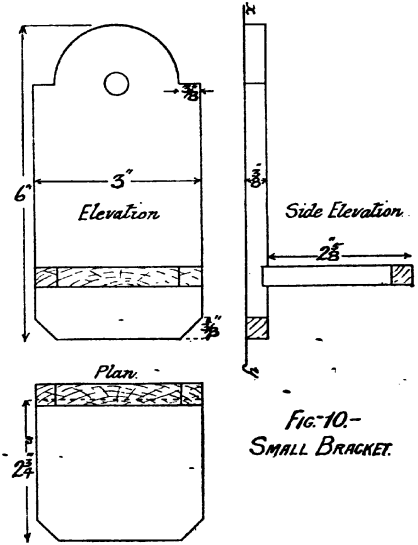


FIG. 10.–
SMALL BRACKET.

Fig. 9. See page 228.

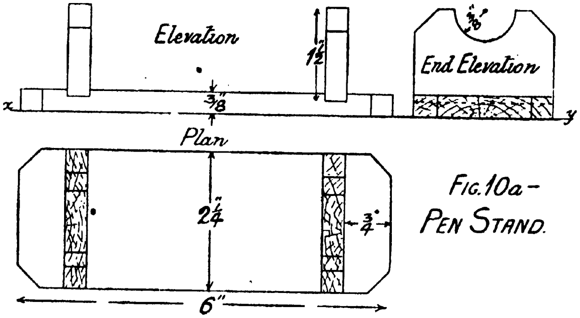


Fig. 10a – Pen Stand.

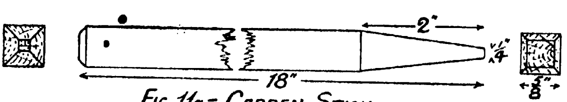


Fig. 11a. – Garden Stick.

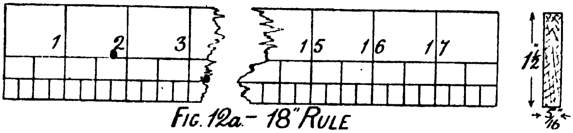
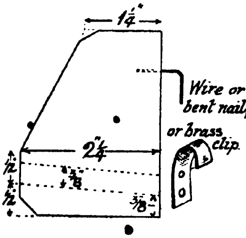


Fig. 12a. – 18" Rule



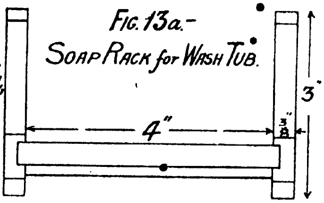


Fig. 13a. – Soap Rack for Wash Tub.

Fig. 12a. See page 228.

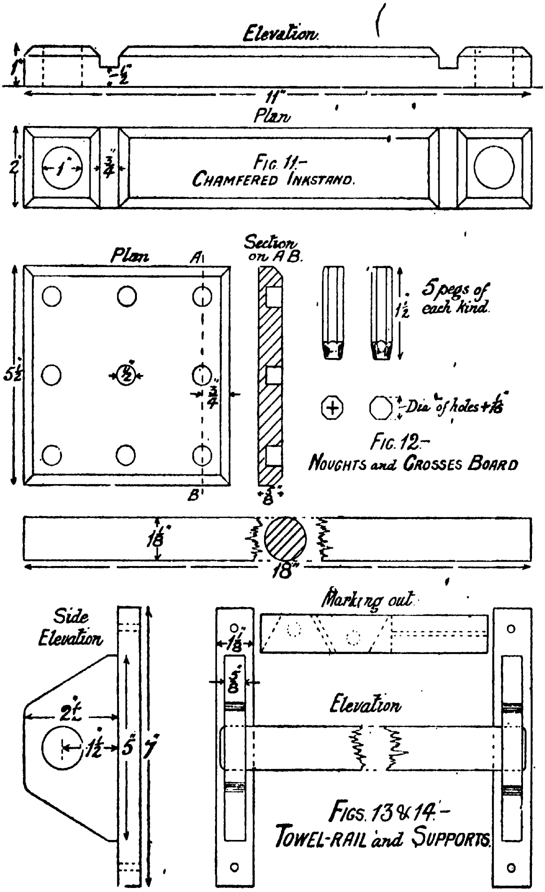


Fig. 12. See page 228.

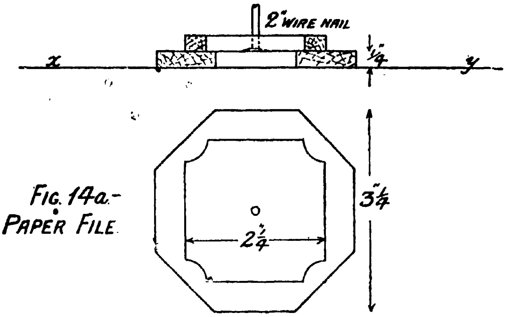


Fig. 14a.- Paper File

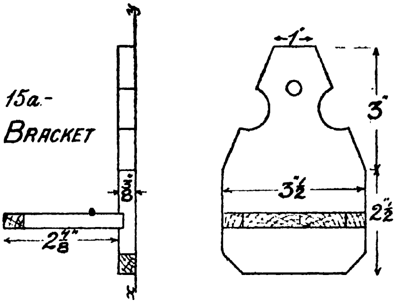


Fig. 15a.- Small Bracket

Fig. 16a.- Tie Rack.

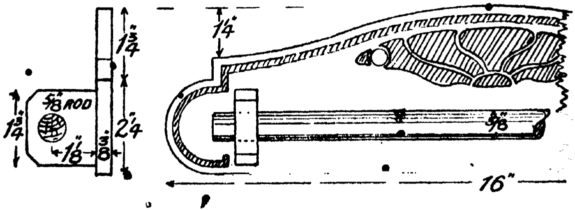


Fig. 16a. • See page 228.

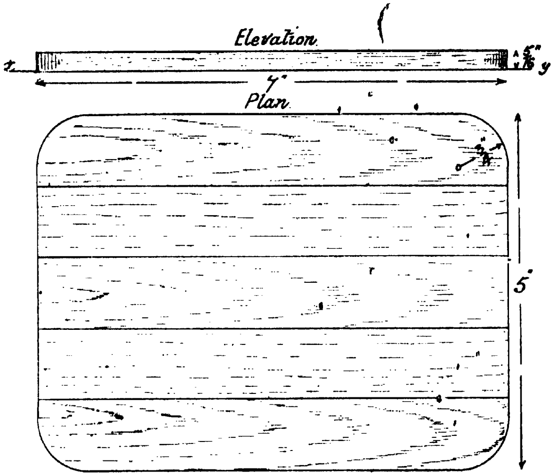


FIG. 15.– TABLE MAT.

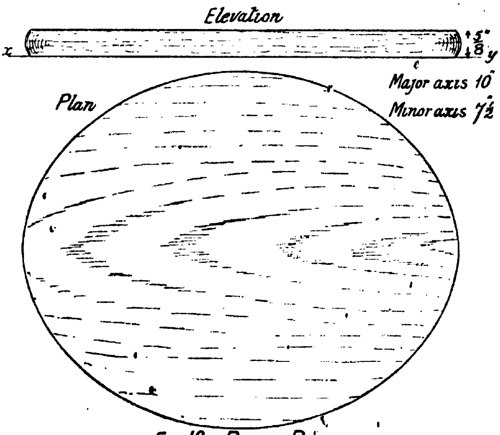


FIG. 16.– BREAD BOARD.

Fig. 15. See page 228.

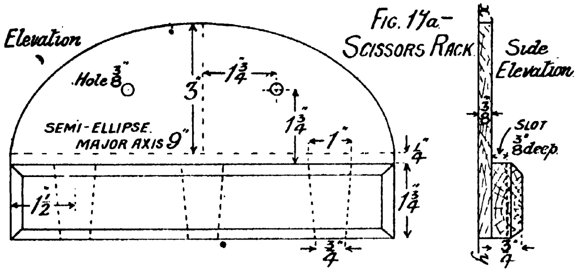


Fig. 17a—Scissors Rack

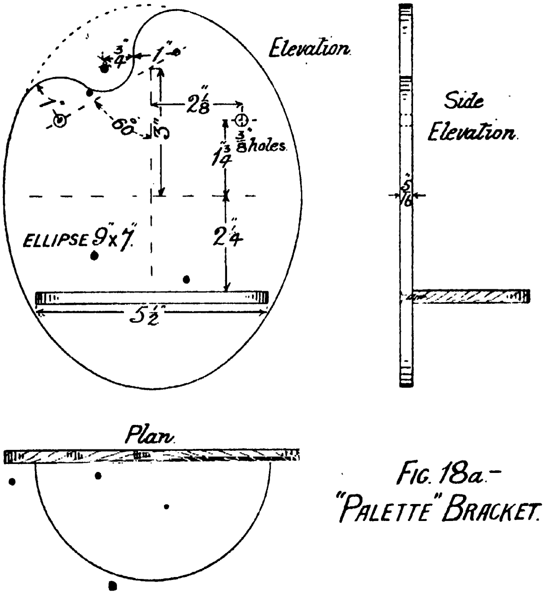


Fig. 18a—"Palette" Bracket

See pages 228, 249

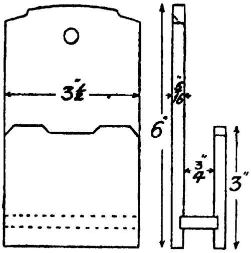


Fig. 17.—Letter Rack

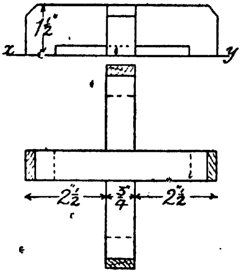


Fig. 18.—Flower-pot Stand.

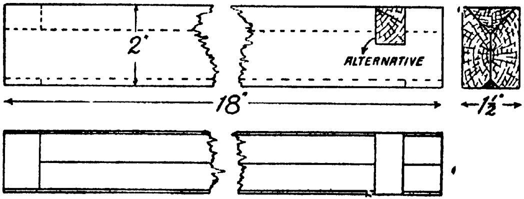


Fig. 19.—"Cradle" or Fillet Board.

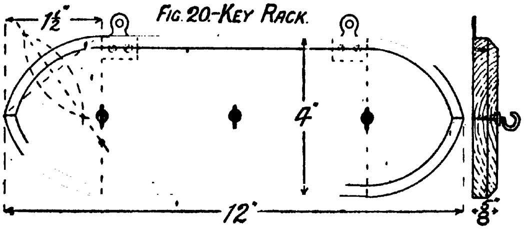
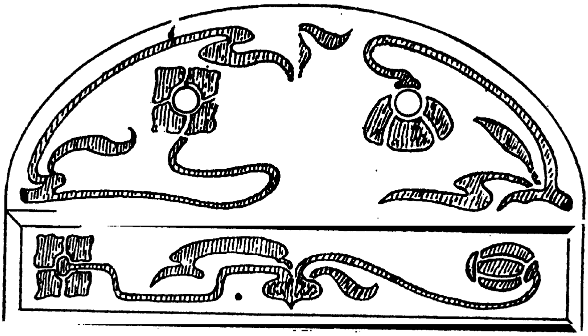


Fig. 20.—Key Rack.



Suggestions for Decoration of 17a & 18a.

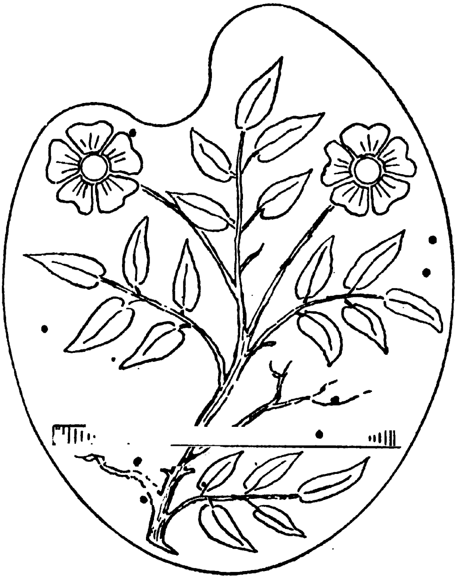


FIG. 19a.

See page 228.

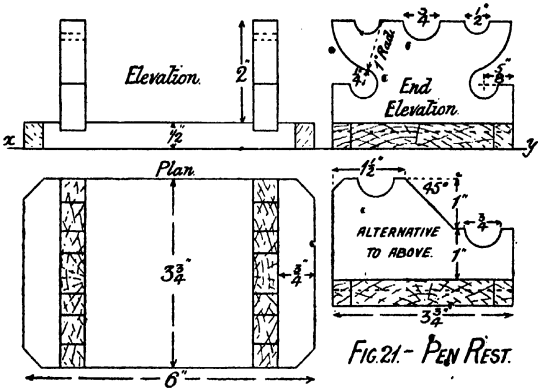


FIG. 21.- PEN REST.

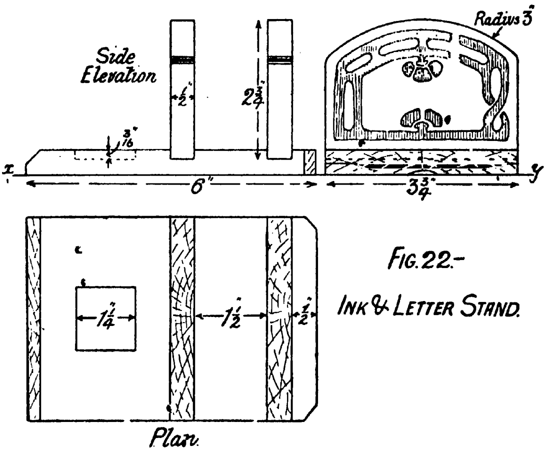


FIG. 22.- INK & LETTER STAND.

Fig. 22. See page 230.

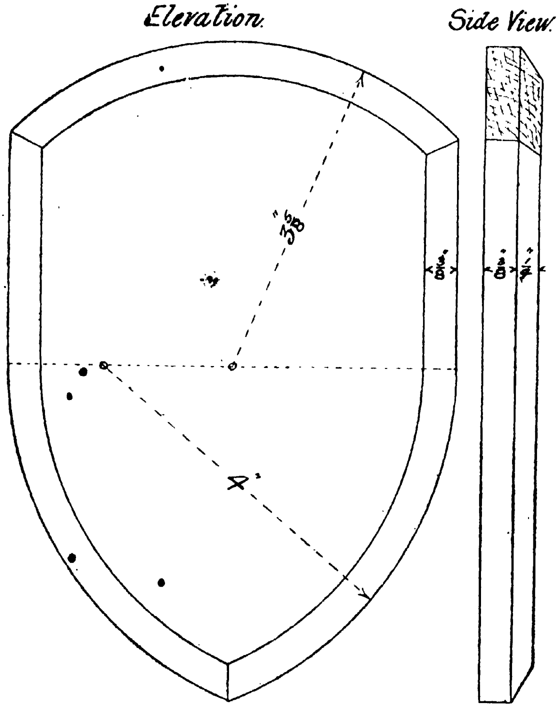


FIG. 23.- CHAMFERED SHIELD.

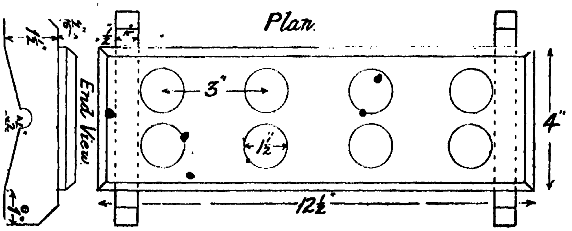


FIG. 24.-EGG STAND.

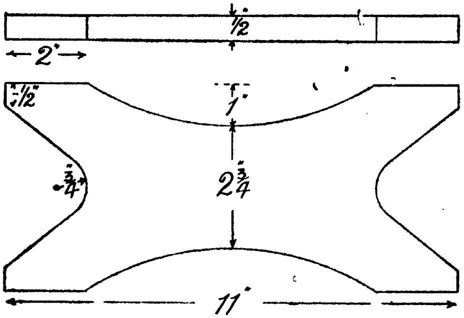


Fig. 25.—Clothes-line Winder.

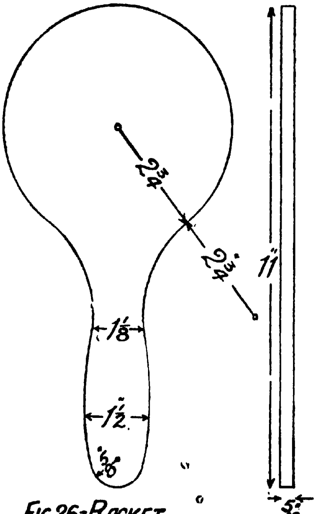


Fig. 26.—Racket.

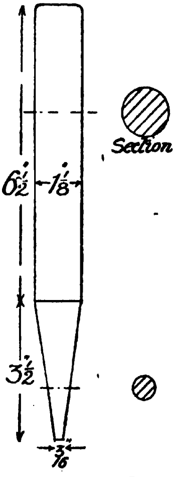


Fig. 27.—Garden Dibble.

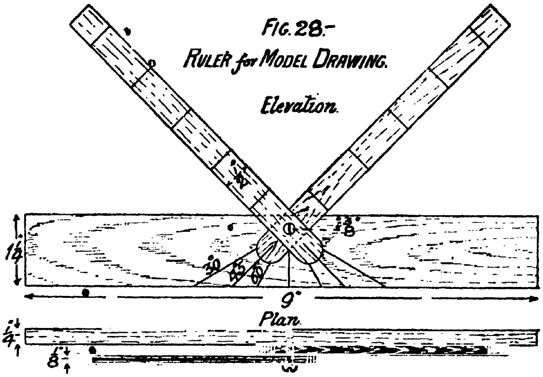


FIG. 28.- RULER for MODEL DRAWING.

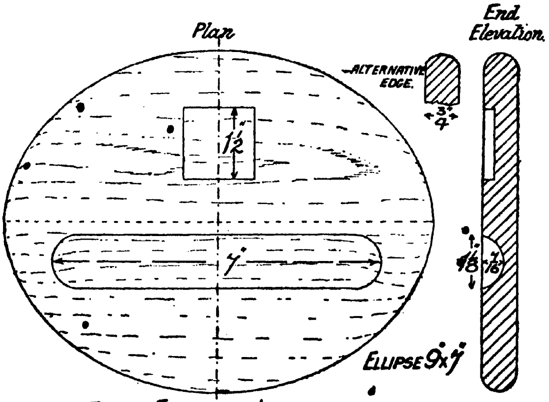


FIG. 29.-ELLIPTICAL INKSTAND.

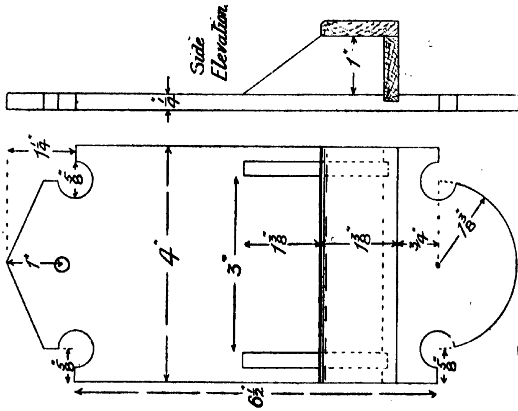


FIG. 31.— DATE CASE.

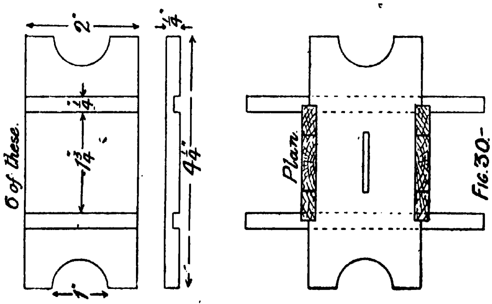
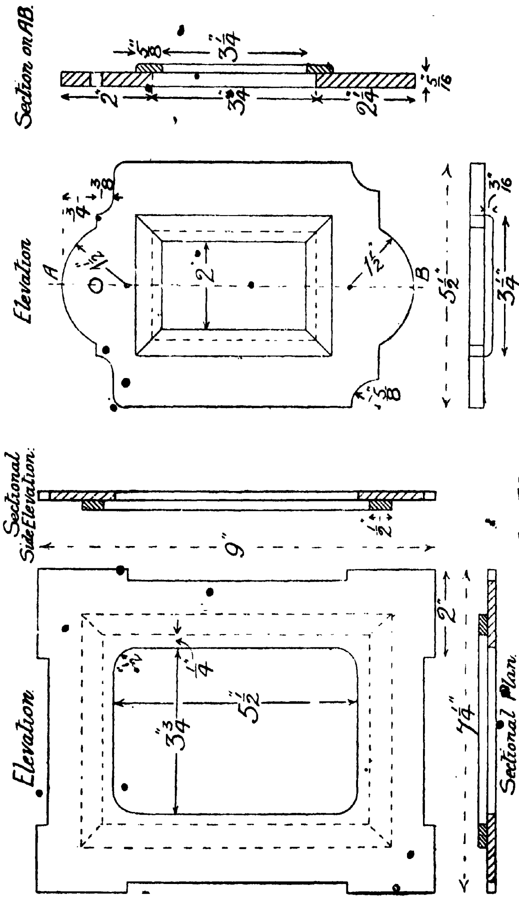


FIG. 30.— PUZZLE MONEY-BOX.



FIGS. 32 and 33.—PHOTOGRAPH FRAMES.

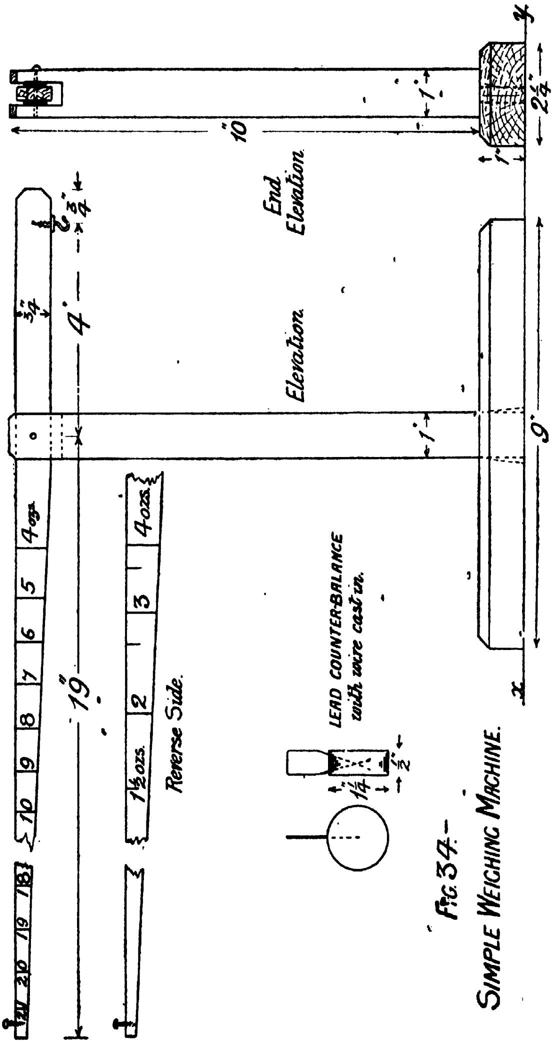


FIG. 34—SIMPLE WEIGHING MACHINE.

See page 230.

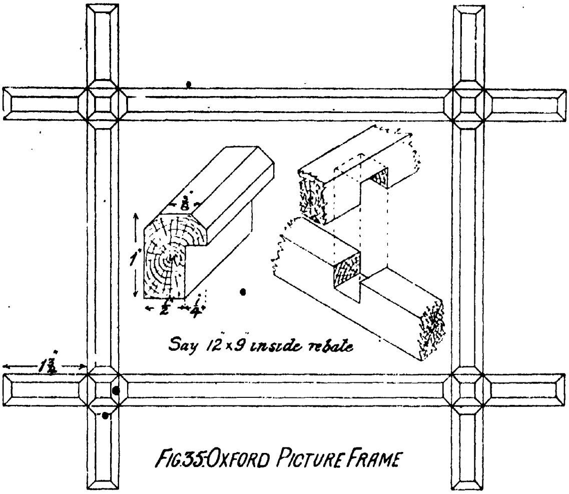


FIG. 35: OXFORD PICTURE FRAME

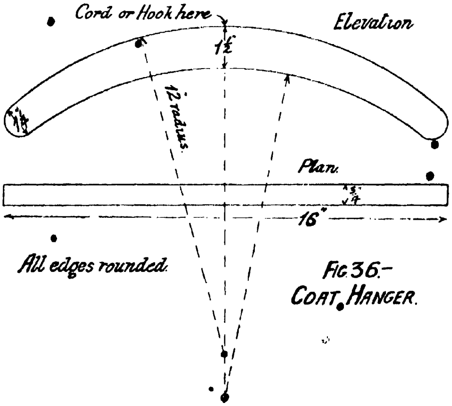


FIG. 36.- COAT HANGER.

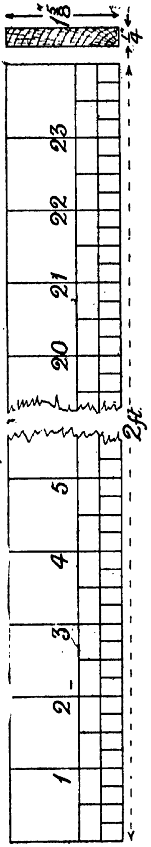


FIG. 37.—2 FT. RULE.

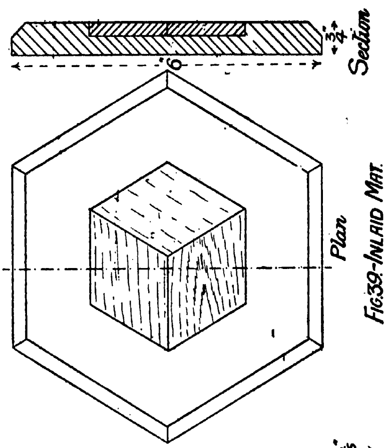


FIG. 39.—INLAID MAT.

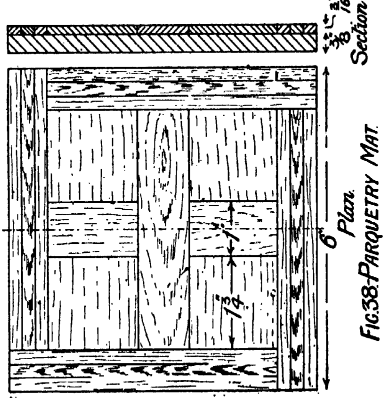


FIG. 38.—PARQUETRY MAT.

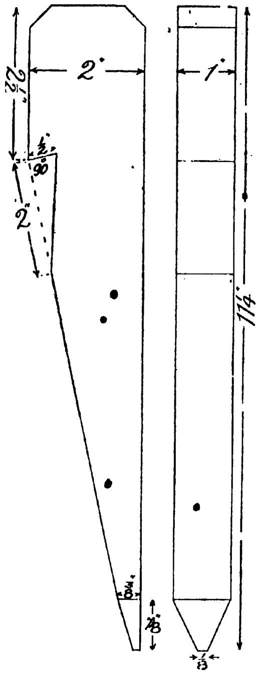


FIG. 40 TENT PEG.

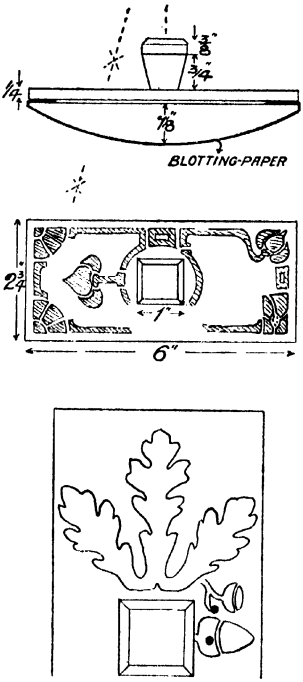


FIG. 41 - BLOTTER.

Fig. 41. See page 231.

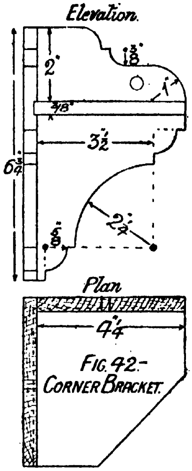


FIG. 42.—CORNER BRACKET.

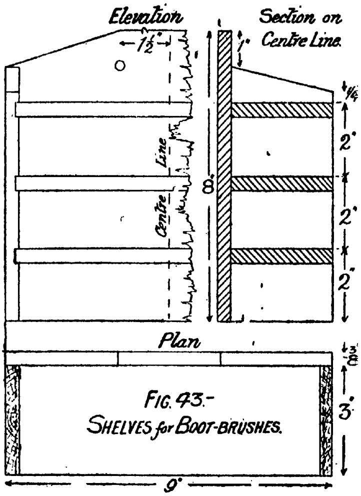


FIG. 43.—SHELVES for BOOT-BRUSHES.

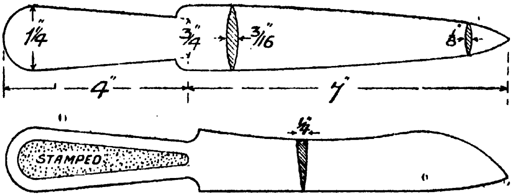


FIG. 44.—PAPER-KNIFE.

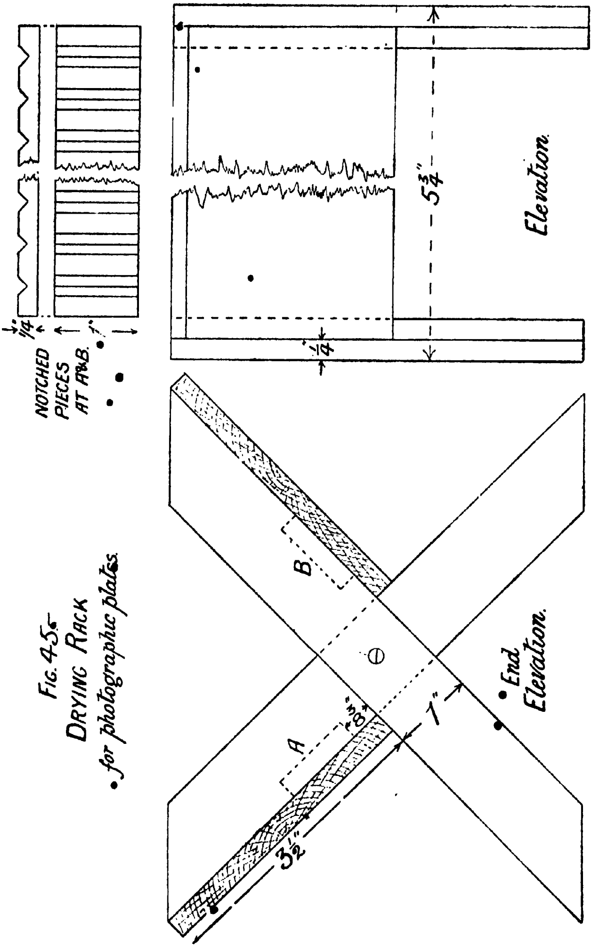


Fig. 45.
Drying Rack
for photographic plates.

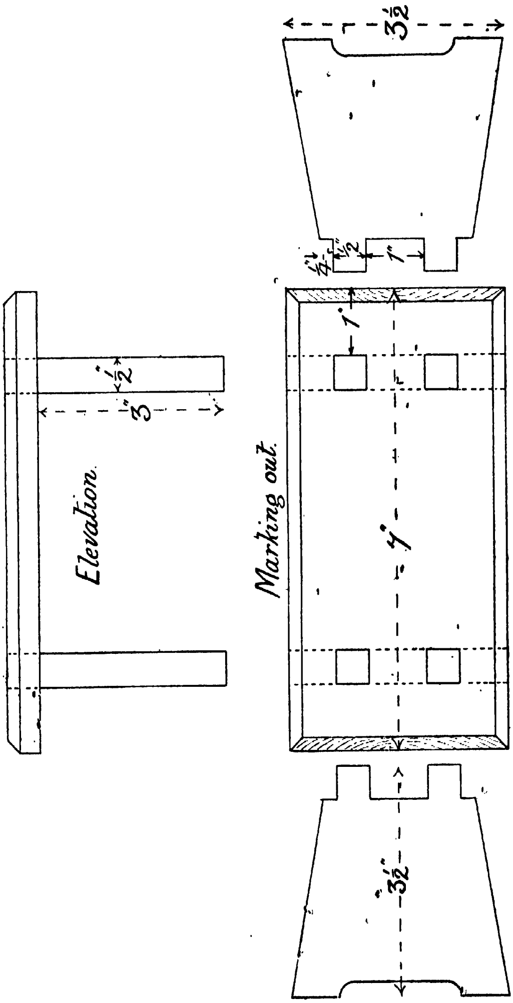


FIG. 46. TOY STOOL.

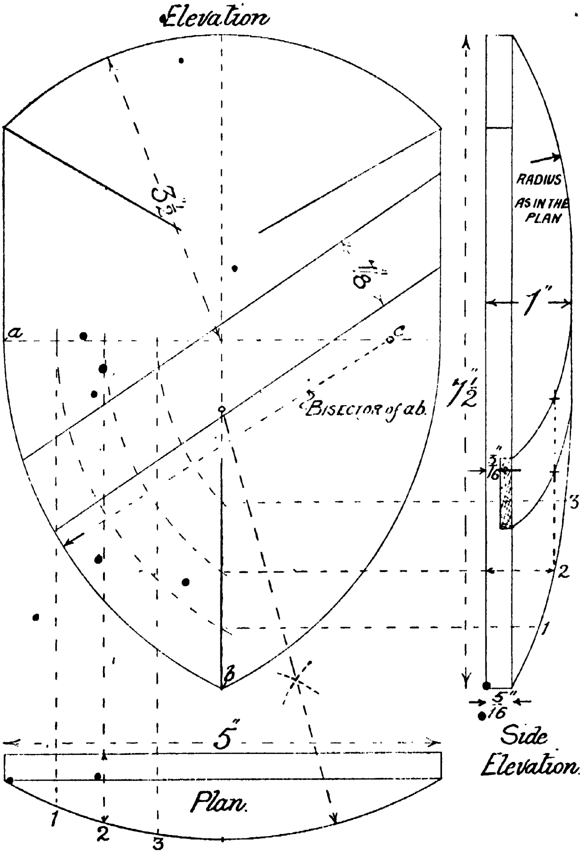


FIG. 47.—A SHIELD.

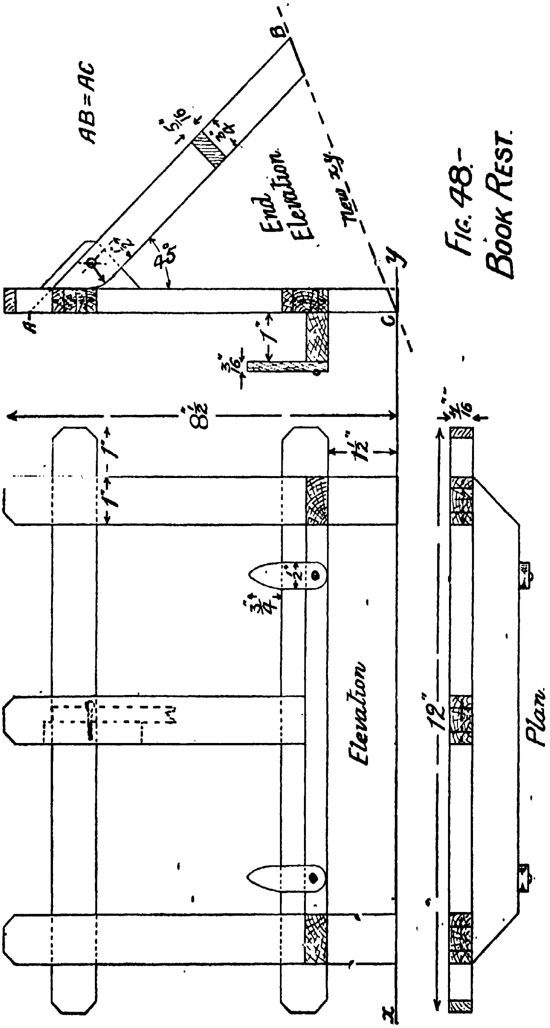


FIG. 48.—BOOK REST.

FIG. 49. HAT RACK.

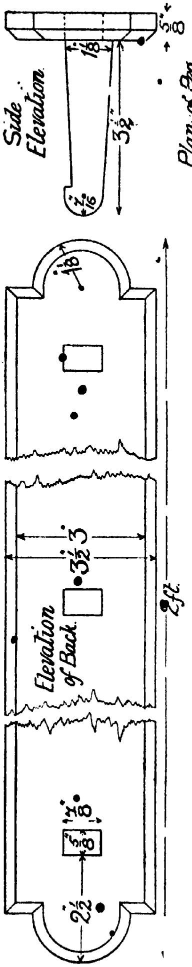
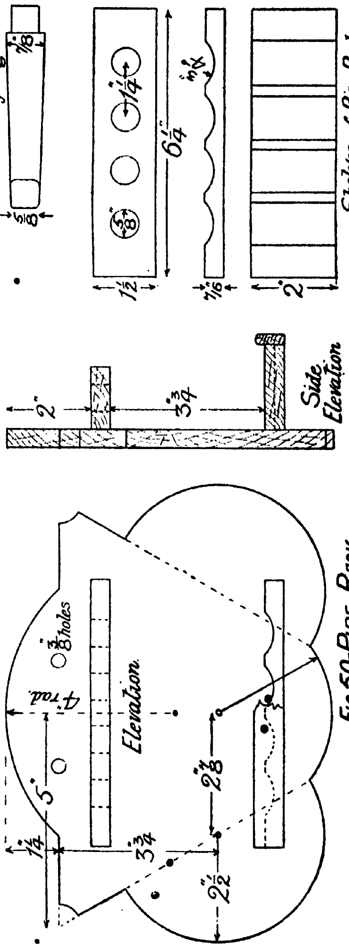


FIG. 50. PIPE RACK.



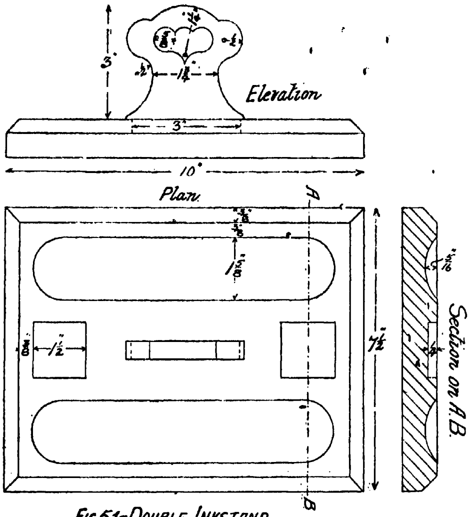


FIG. 51.-DOUBLE INKSTAND.

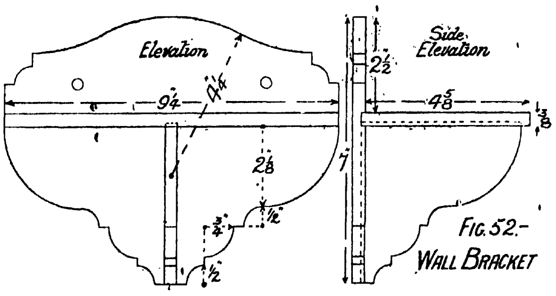


FIG. 52.-
WALL BRACKET

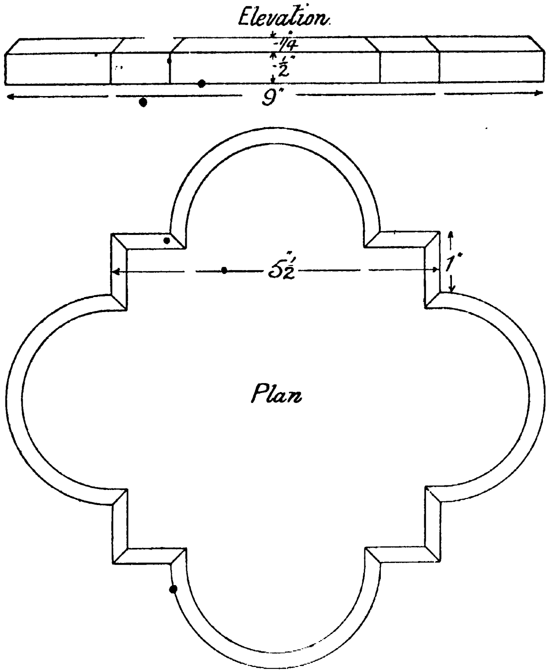


Fig.-53-Bread Board.

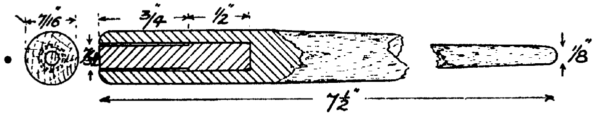


Fig.-54-Penholder.

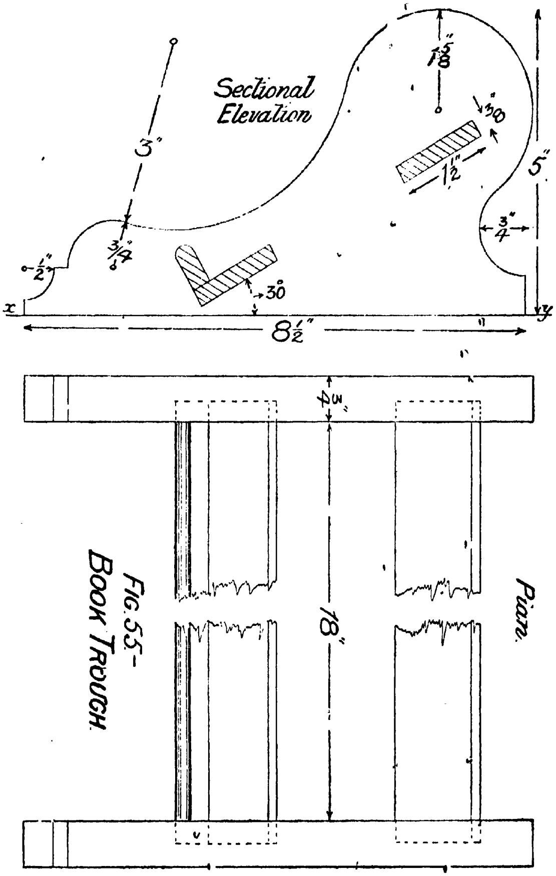


FIG. 55— BOOK TROUGH.

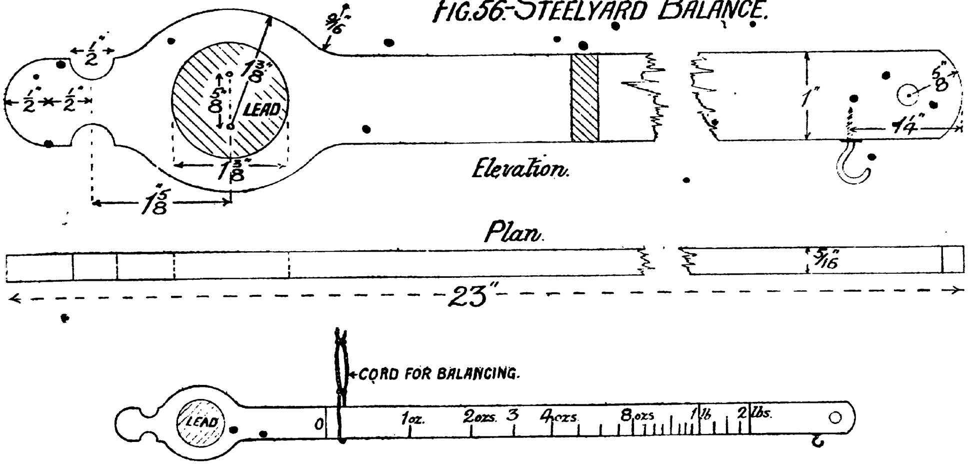
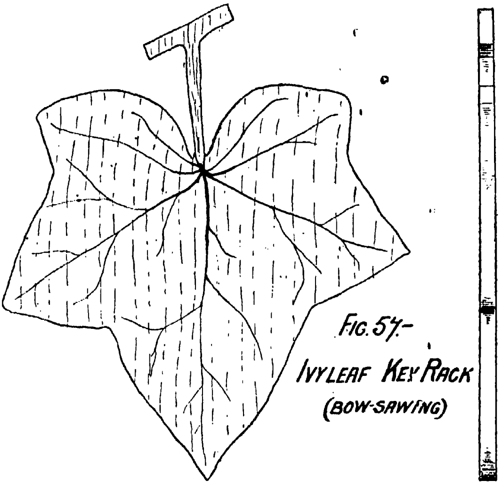


FIG. 56.—"STEELYARD" BALANCE.

See page 231.



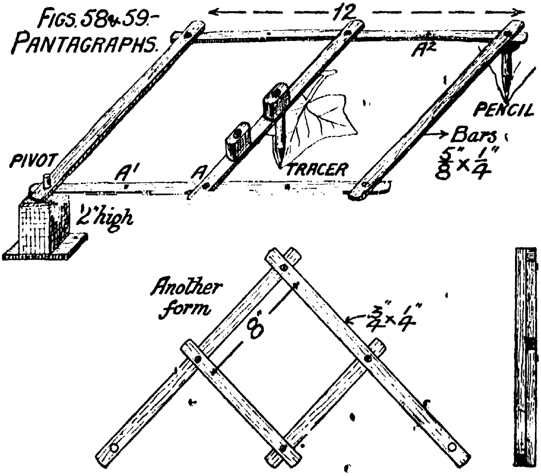


Fig. 58. See page 231.

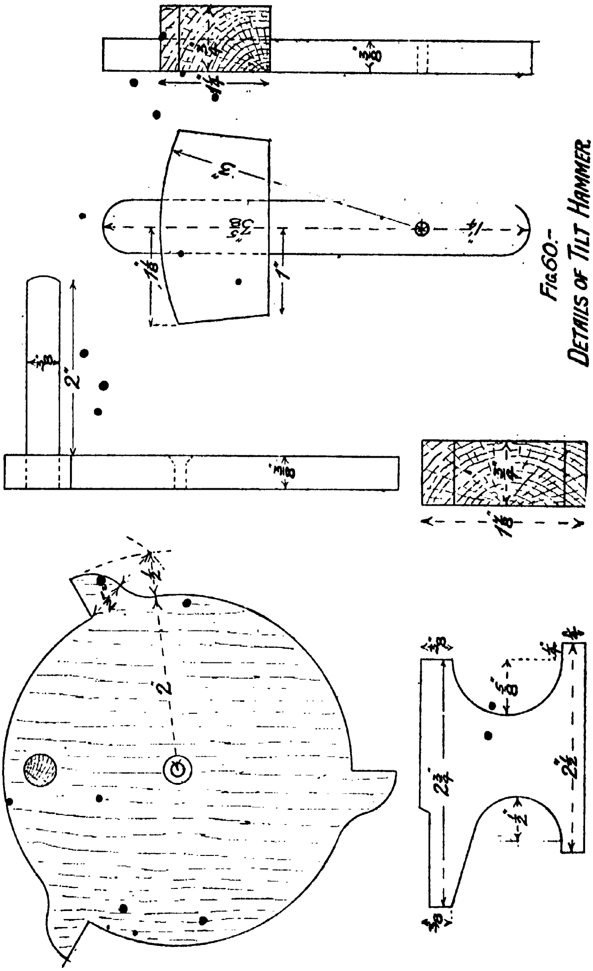


FIG. 60.—DETAILS OF TILT HAMMER.

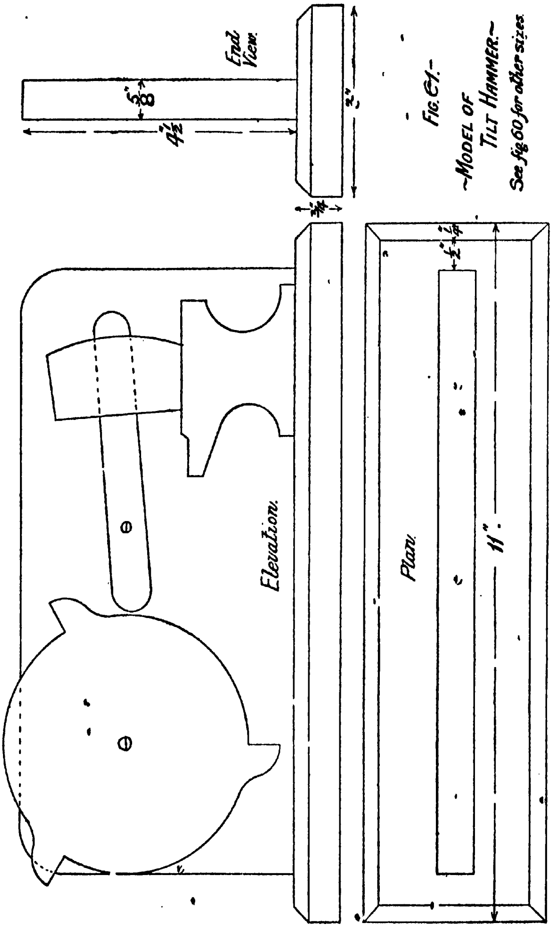


Fig. 61.—

—Model of Tilt Hammer.—

See fig. 60 for other sizes.

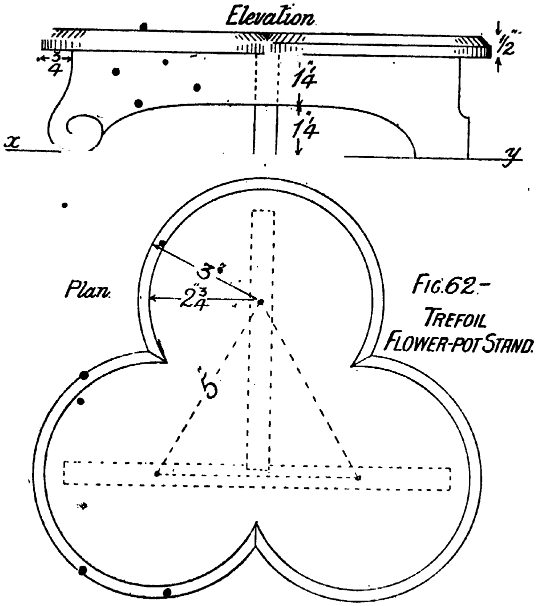


FIG. 62.– TREFOIL FLOWER-POT STAND.

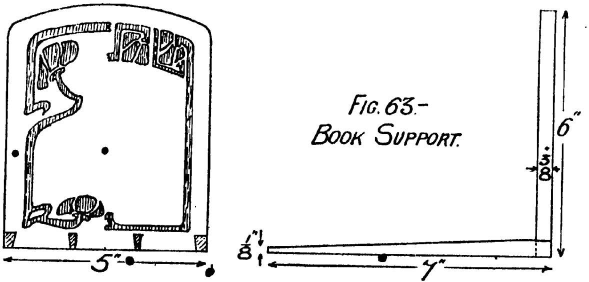


FIG. 63.– BOOK SUPPORT.

Fig. 63. • See page 232.

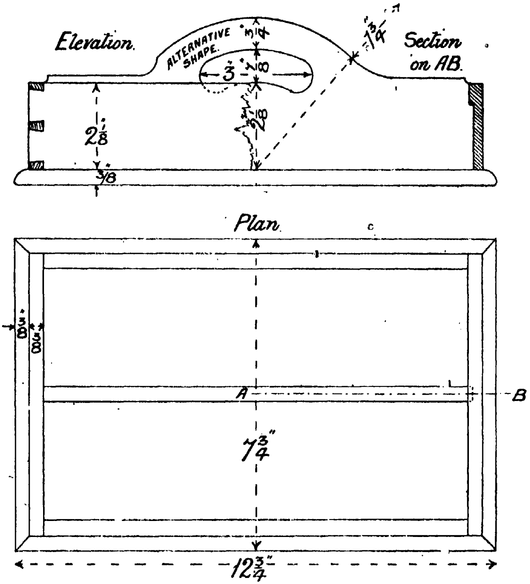


FIG. 64—KNIFE BOX.

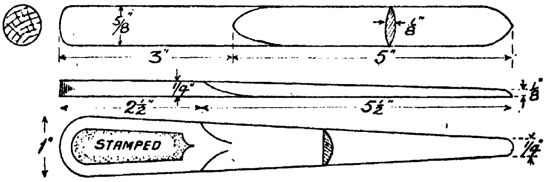


FIG. 65—ENVELOPE OPENERS.

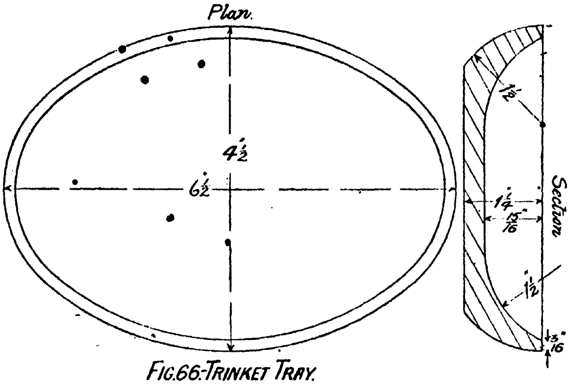


FIG. 66.—TRINKET TRAY.

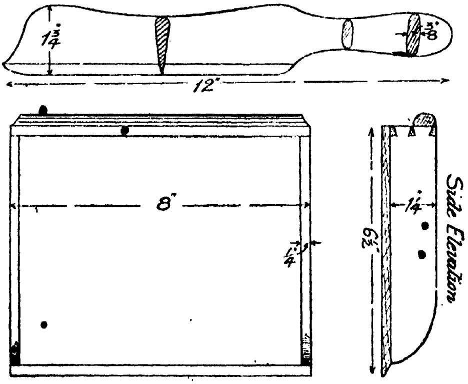


FIG. 67.—CRUMB TRAY and SCRAPER.

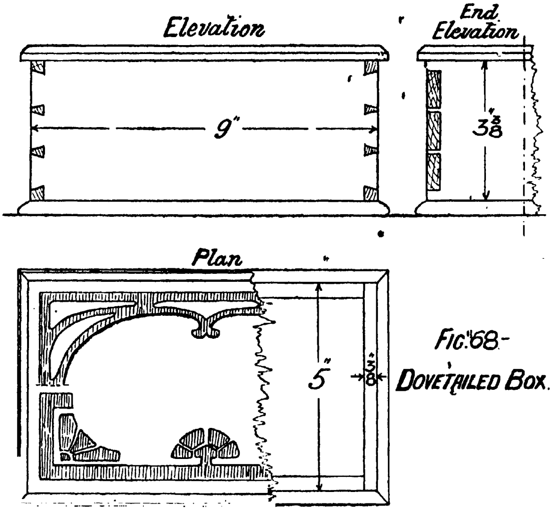


FIG. 68 - DOVETAILED BOX.

FIG. 69 - WRITING DESK.

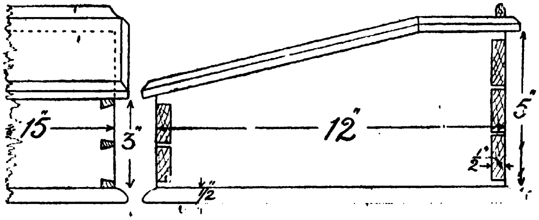


Fig. 68. See page 232.

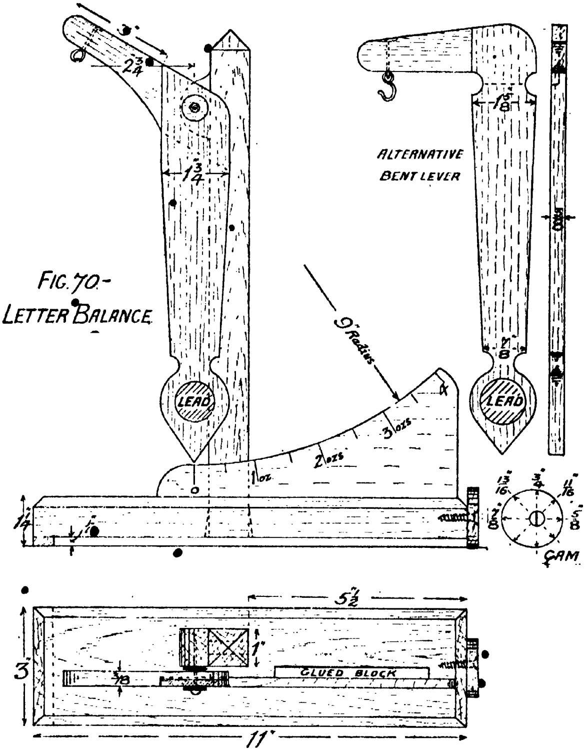


FIG. 70 - LETTER BALANCE

See page 232.

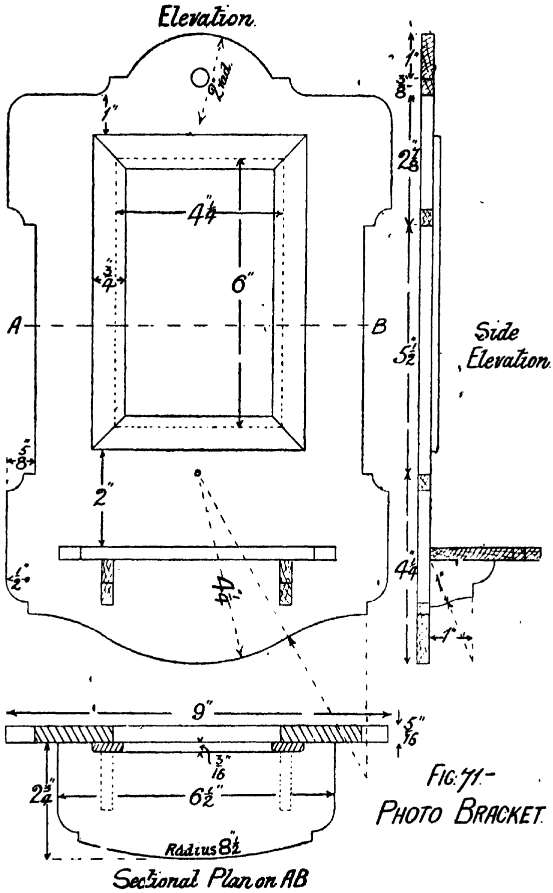


FIG. 71.—PHOTO BRACKET.

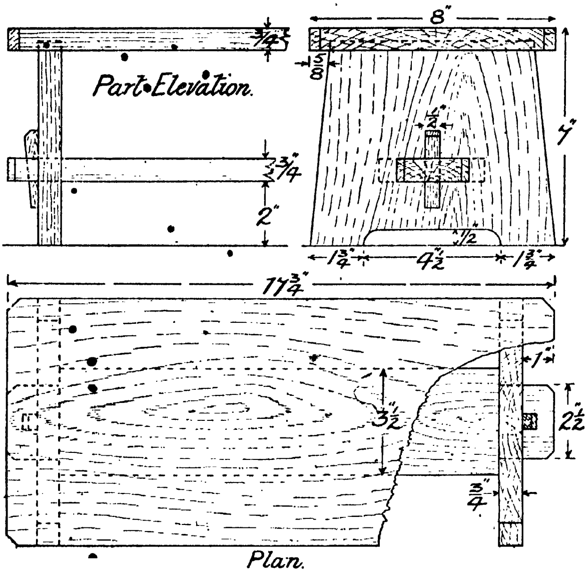


FIG. 72.—FOOT STOOL.

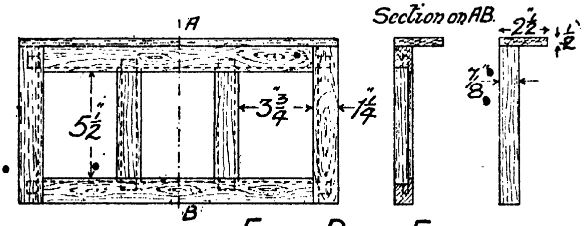
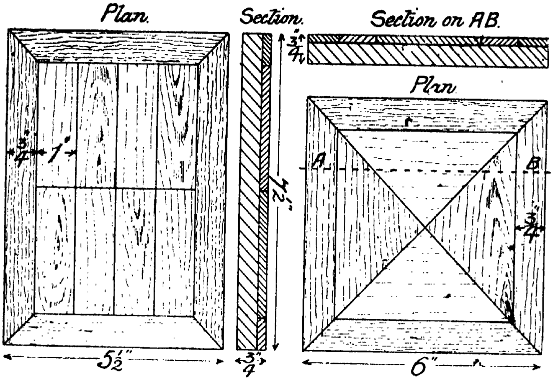
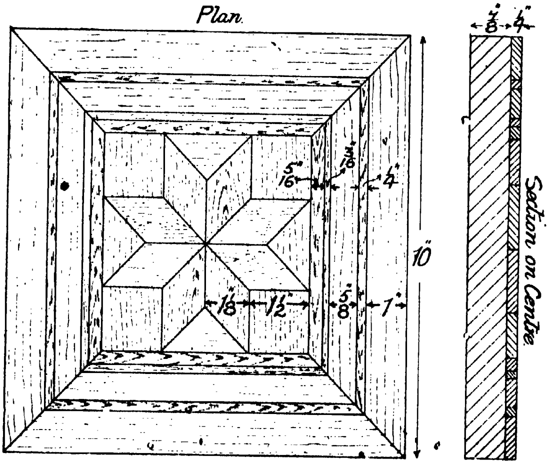


FIG. 73.—PHOTO FRAME.



Figs. 74, 75 & 76.-
Parquetry Mats.



See page 232.

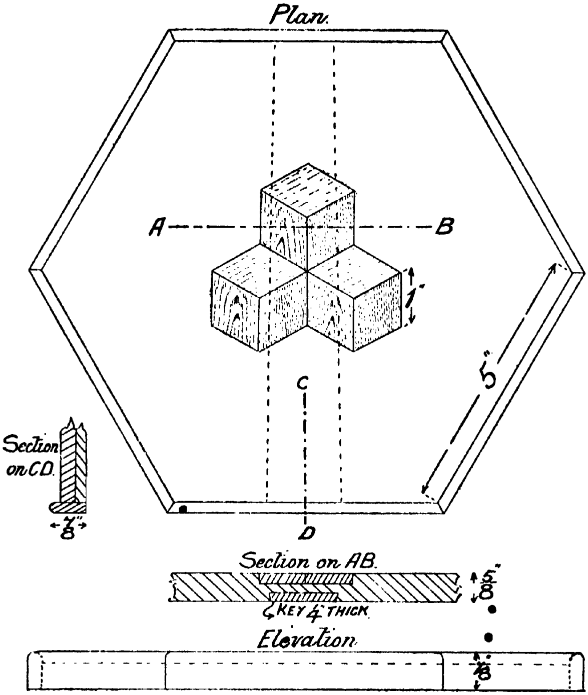


FIG. 77.—HEXAGONAL INLAID STAND.

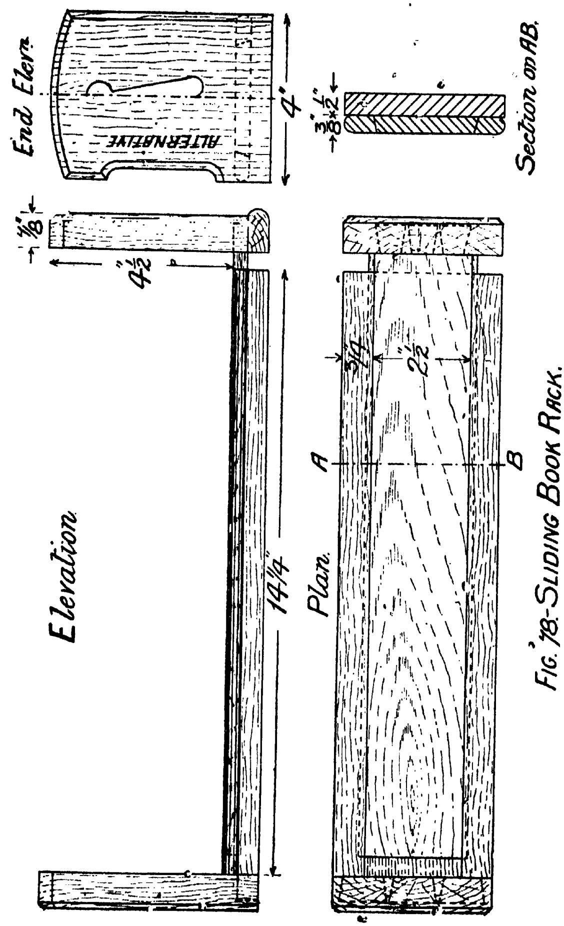
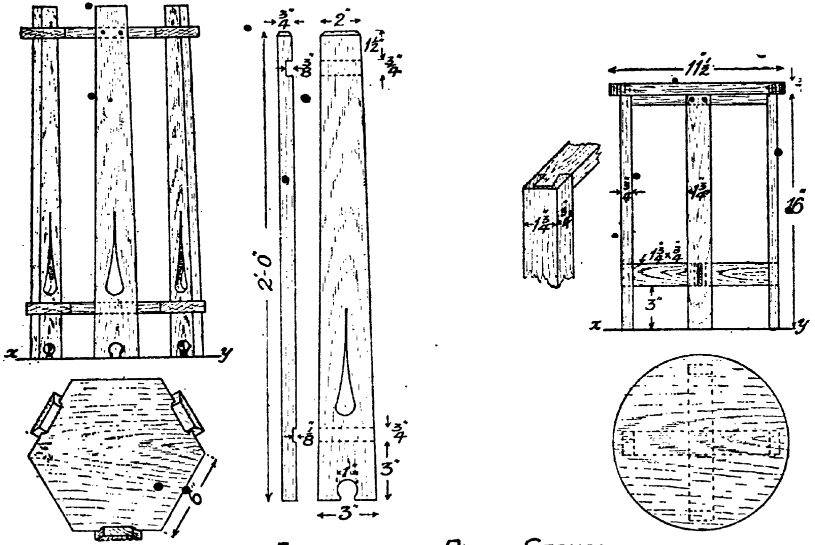


FIG. 78. SLIDING BOOK RACK.



FIGS. 79 and 80.-PLANT STANDS.

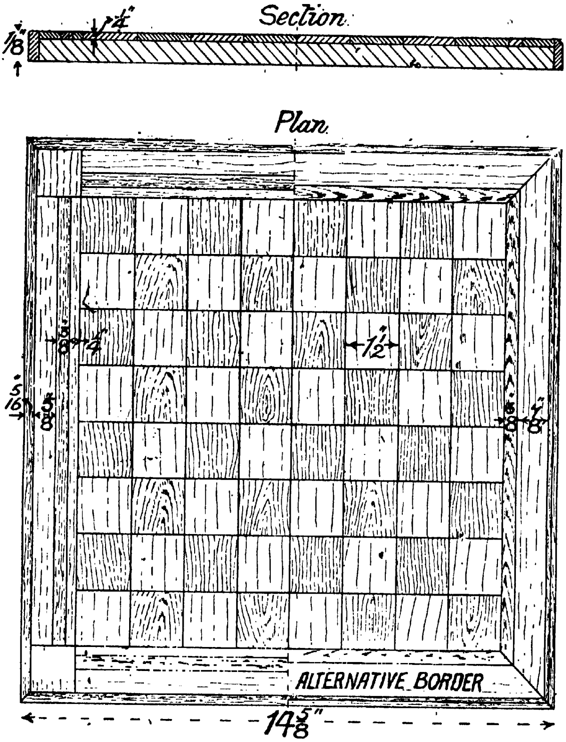


FIG. 81.—CHESS BOARD.

See page 232.

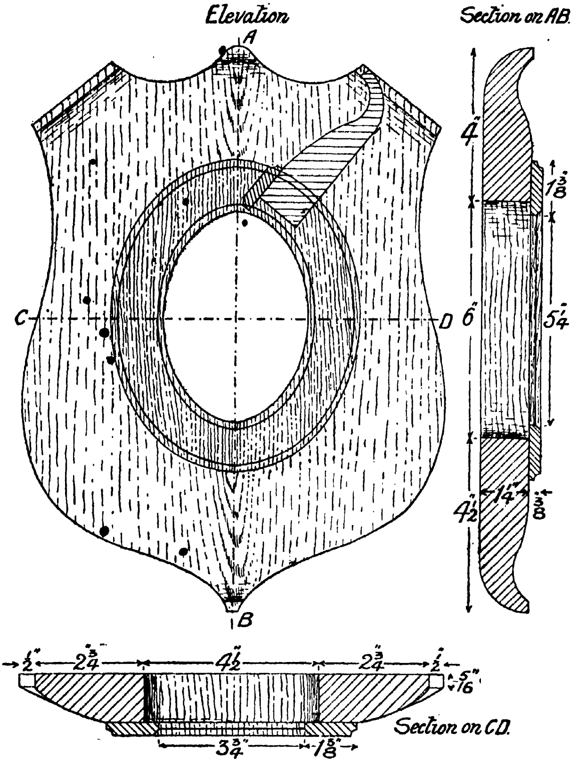


FIG. 82.—LARGE PHOTO SHIELD.

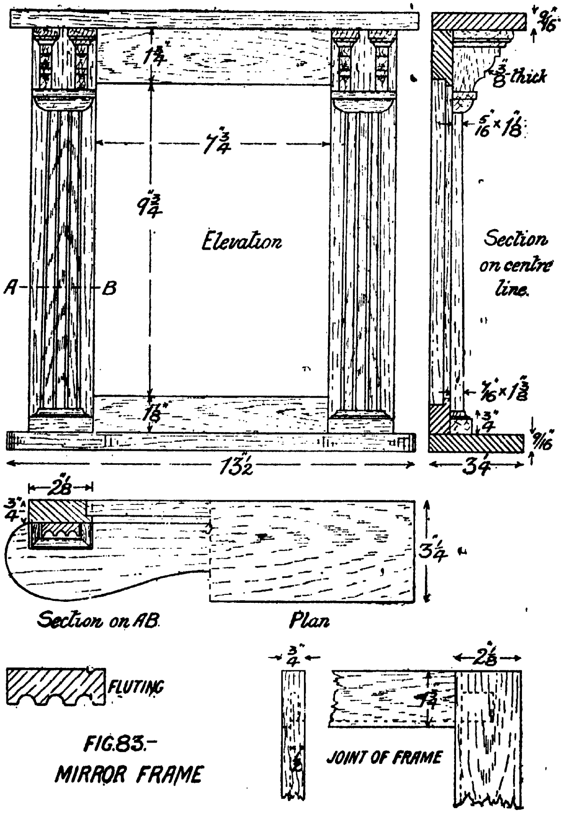


FIG. 83.—
MIRROR FRAME

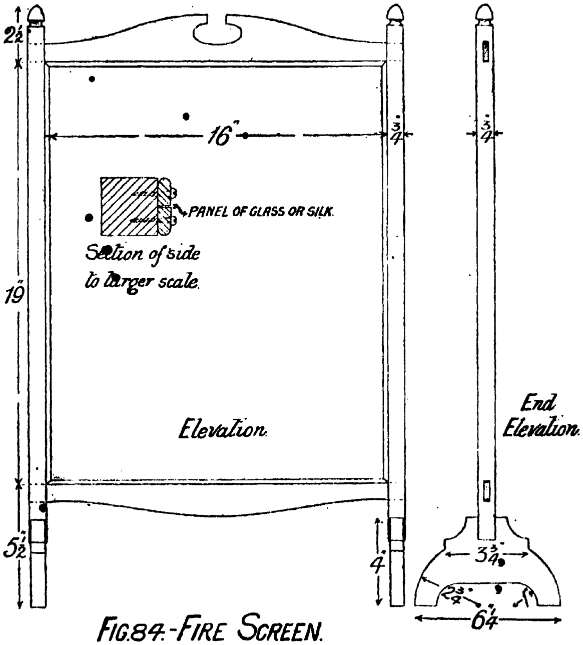


FIG. 84.—FIRE SCREEN.

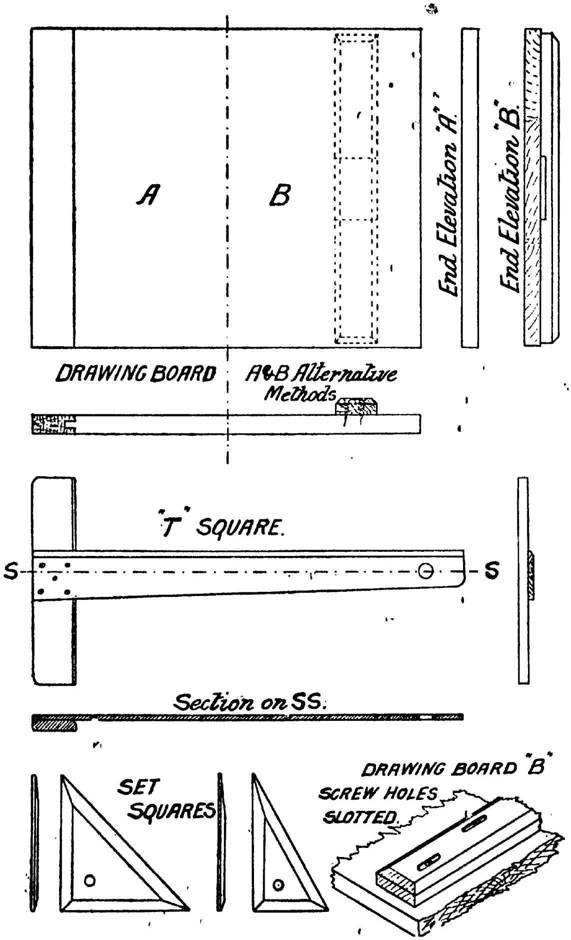


Fig. 85.—Drawing Board, Etc.

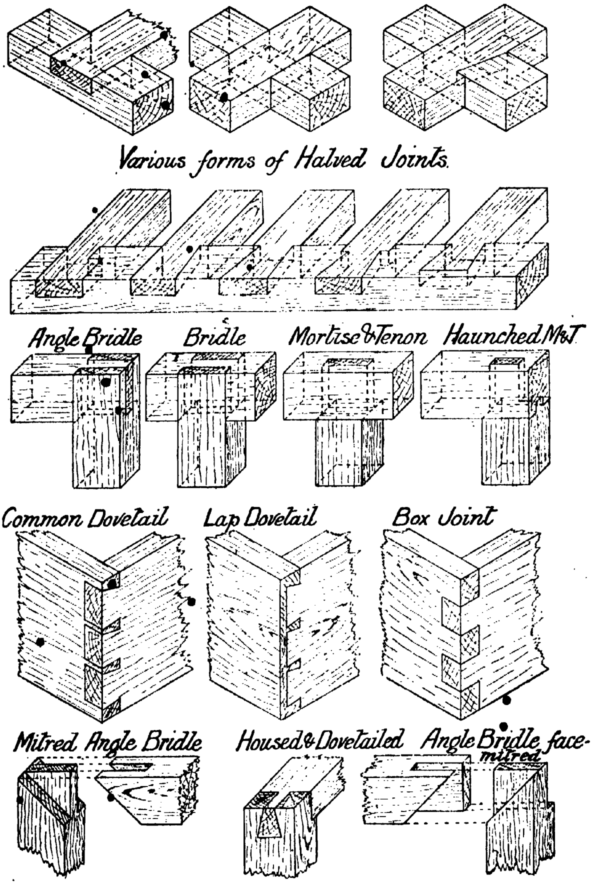


Fig. 86.—VARIOUS JOINTS.

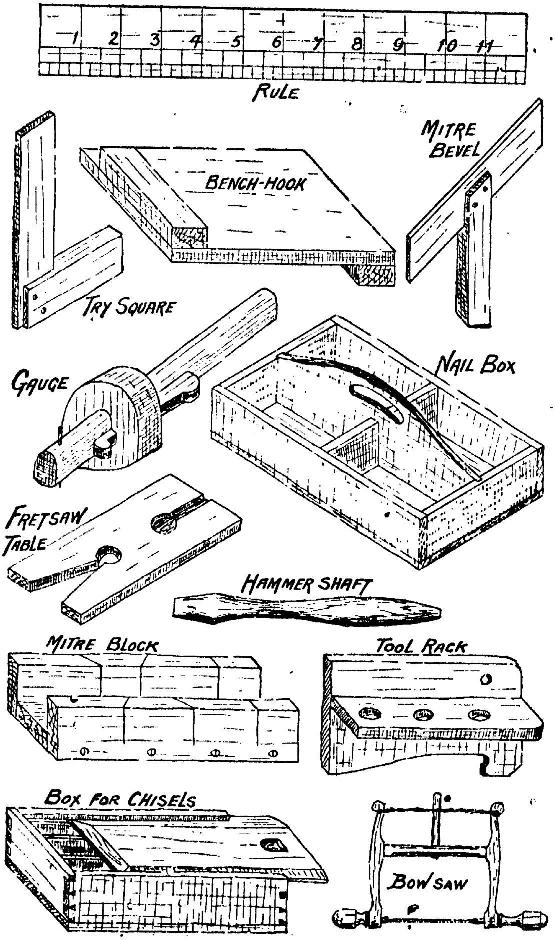


Fig. 87.—Tools and Appliances.

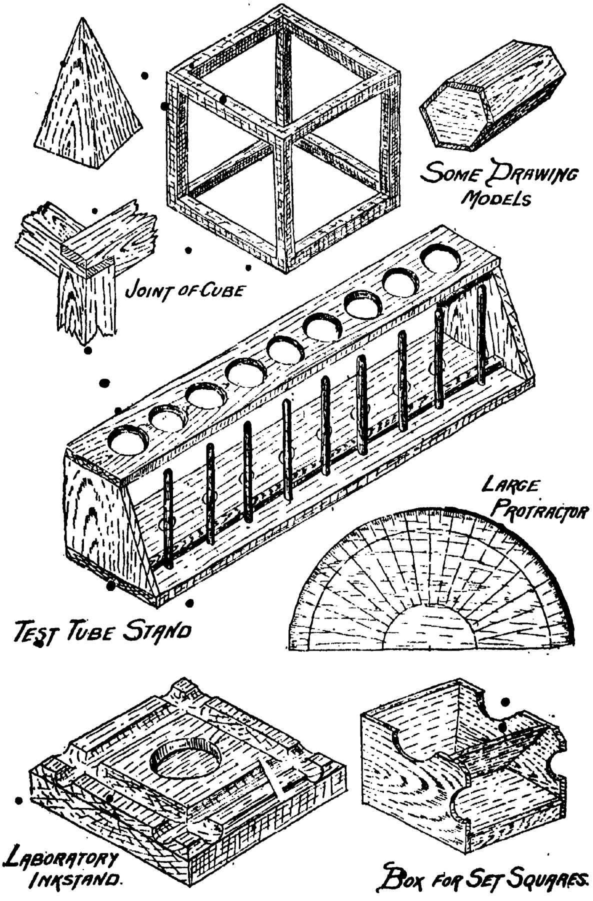


Fig. 88.—School Apparatus.

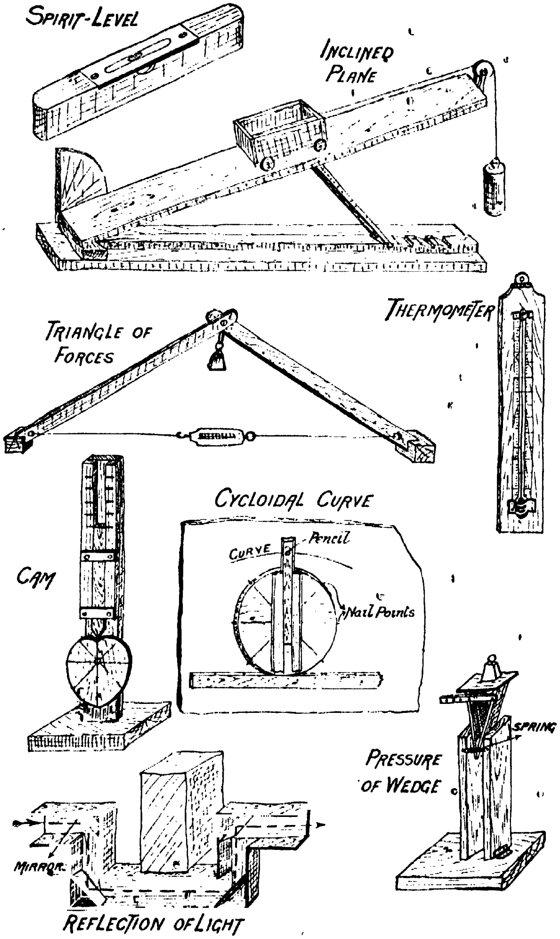


Fig. 89.—School Apparatus.

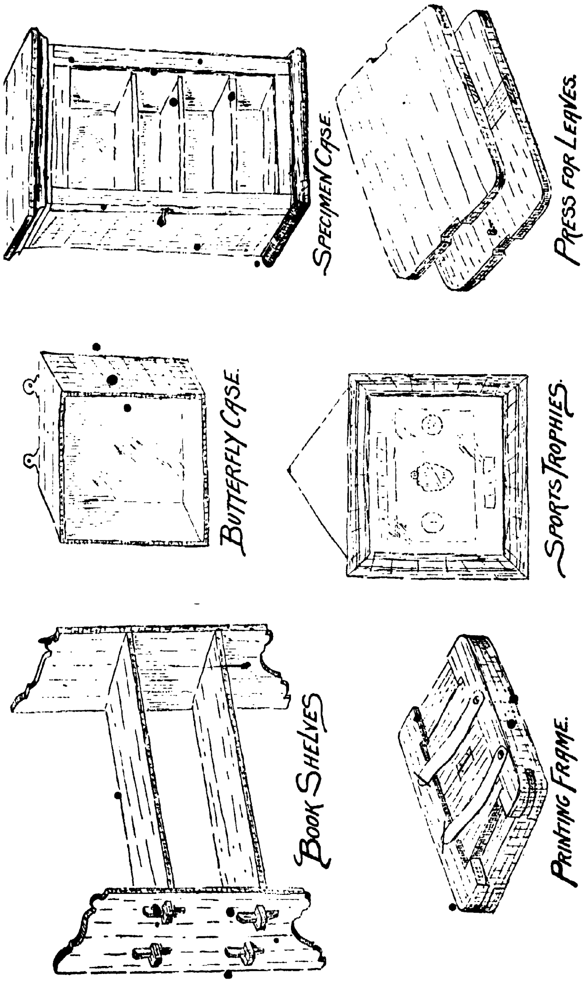

Specimen Case.
Press for Leaves.
Butterfly Case.
Sports Trophies.
Book Shelves
Printing Frame.

Fig. 90.—Hobbies.

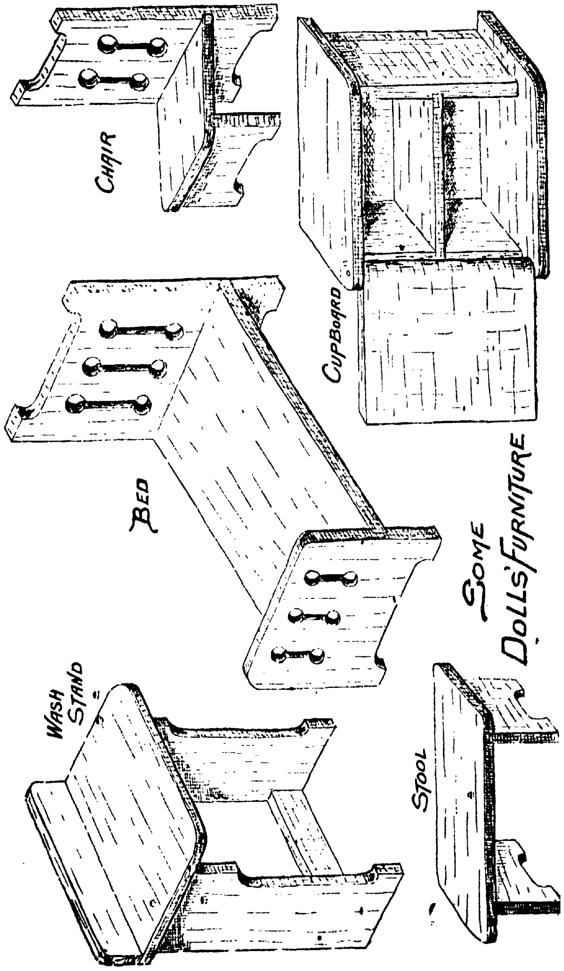


Fig. 91

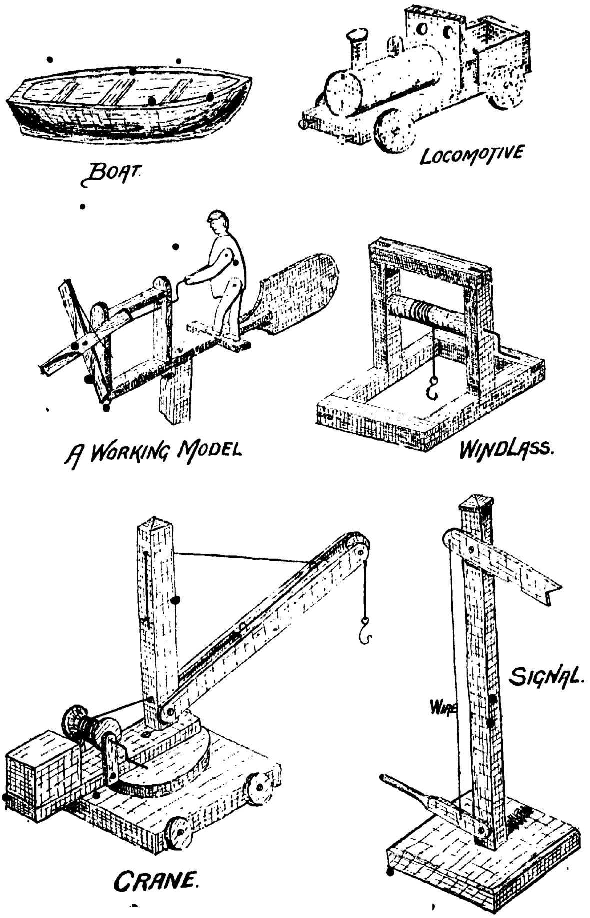


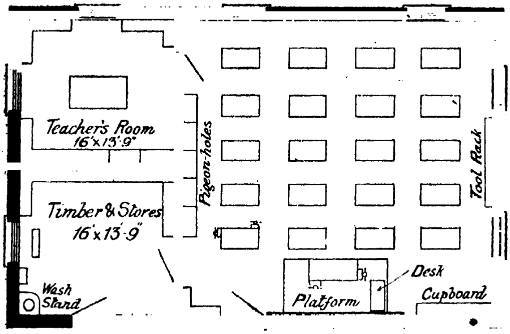
Fig. 92.—Boys' Toys.

CHAPTER XIII

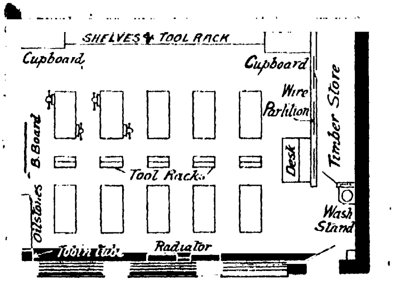
THE HANDICRAFT ROOM AND ITS EQUIPMENT

THE planning of a handicraft room depends upon circumstances that vary considerably with different school authorities and localities. This being so, it has been thought better to present plans of two centres that may be considered typical of this country and of America.

At present in England what is known as the " centre " system prevails. A centre, or manual training room, is built to accommodate either twenty or forty pupils, who attend for one whole session, either morning or afternoon, each week. A forty or double centre is worked by two teachers, one being the assistant. Thus a centre will take either 200 or 400 boys during the five days that the schools are open. It is seldom that schools have a sufficient number of boys eligible for manual training grant to supply the whole of the number for a double or forty centre, so that several schools are drawn upon by some centres. An objection to the handicraft room being away from the school buildings is that it tends to give rise to a feeling in the minds of the scholars that the work is not an integral part of their school studies. A better plan would be for each school to have its own handicraft room built as a part of the school building, instead of being away from the main block, and treated as an ordinary class-



Plan of Sloyd Room, 32' x 28', fitted with 20 single benches.
— From G. Larsson's "Sloyd Theory & Practice."



Plan of a typical London Manual Training Room,
34'-6" x 22', fitted with 10 double benches.

room. Such a room could be made available for the manual training of the lower standards as well, if not fully occupied by the woodwork classes as at present constituted. A modification of the existing type would be necessary; among other things seats being provided and suitable provision made for the necessary drawing, either by means of drawing desks or some modification of the bench top. In such a case there would be no need to resort to the ungainly "forty" centre, with its two teachers; the rooms being planned for twenty pupils with facilities for increasing the accommodation when the room was being used for simple forms of handwork demanding less room and fewer tools. A system of individual instruction, such as is suited to the teaching of woodwork, necessitates some pupils being at work while others are being shown what to do. The noise caused by the tools of the working section is troublesome to the teacher sometimes even in a twenty centre, while in a forty centre the two teachers must have sections of boys, the noise of whose tools often conflicts with the voices of the teachers as they demonstrate how the work should be done. The excuse often urged for the forty centre is that it forms a training ground for the younger teachers, but surely such a rich nation as ours can afford a system of training that shall not be carried out so much at the expense of the pupils. A handicraft room should be well lighted, a northern light being preferable. A floor space of 600 square feet for twenty pupils may be considered the minimum. As the work causes a certain amount of dust the room should be planned so as to be easily cleaned. All cupboards are better "built in" so as to avoid the small spaces so difficult to keep clean that occur with movable furniture.

The tool racks should be so constructed that each boy has his set of tools near at hand, responsibility can be easily fixed then in case of disorder.

The benches should be strong and firm and fitted with instantaneous grip vices with hardwood cheeks. Much can be done to broaden the scope of the work if a lathe, small vice for metalwork, small bench anvil, and a supply of sheet brass, wire, lead, Venetian strip-iron, tin, etc., are added to the customary equipment.

A list of tools and materials that have been found suitable for courses of woodwork such as are outlined in the woodwork section of this book, is given below.

EQUIPMENT FOR TWENTY PUPILS

10 Bench brushes.
Bits : 3 sets of centre bits, 1¼″, 1″, ⅞″, ¾″, ⅝″, ½″, ⅜″, ¼″.
6 pin bits, assorted sizes.
2 wood countersinks.
2 metal do.
3 Braces, American pattern.
10 Bradawls, assorted sizes.
4 Bevels.
5 Compasses, wing.
Cramps : 6—6″ G cramps.
2 Sash cramps, 24″.
Chisels : 5—⅛″ Firmer.
10—¼″ ,,
10—⅜″ ,,
20—½″ ,,
5—⅝″ ,,

Chisels: 20—¾" Firmer.
20—1" ,,
4—¼" Mortice.
4—⅜" ,,

2 Cork rubbers.
5 Files, assorted.

Gauges : 20 marking.
1 cutting.
3 mortice.

1 Glue pot and brushes.
Gouges, a few selected (inside and outside).
1 Grindstone with Ilsley's patent grinding apparatus.
20 Hammers.
2 Leather strops.
20 Mallets.
20 Marking knives.
2 Oil cans.
3 Oilstones.
2 Oilstone slips.
2 Pincers.

Planes : 20 Jack planes, 1¾" irons, with sunk handles, or small iron planes 1¾" blade.

The Stanley adjustable wood plane, an iron plane with a beech sole, is an excellent type for manual training work.

2 Rebate planes.
4 Trying planes, 2¼" irons.
6 Smoothing planes, 1¾" irons.
Pliers.
6 Punches.
20 Iron rules, 2 ft., marked either ⅛ths and $\frac{1}{16}$ths, or $\frac{1}{16}$ths and m.m. (metric measure).

Saws : 4 Bowsaws, 8", with spare blades.
2 Bowsaws, 12",

Saws: 6 Handsaws, 22″.
2 Padsaws, with spare blades.
20 Tenon saws, 10″.
10 Screwdrivers and 2 small do.
6 Sloyd knives.
5 Spokeshaves, malleable iron, round face.
5 Spokeshaves, malleable iron, flat face.
2 Try squares, 12″.
20 Try squares, 4½″.

Blackboards, Chalk Compasses, Chalk, Brads and Screws (various sizes), Brass pins, 1 Gong, Glass-paper, Glue, Oil (linseed and sweet), T square and Set squares and Dusters (for blackboard), Soap, Towels.

Benches (preferably single).
Tool racks.
Bench hooks.
Shooting boards.
Sawing trestles.
Teacher's desk.

DRAWING MATERIALS AND STATIONERY

Drawing books, 12″ × 10″.
Drawing paper, 15″ × 11″.
Drawing pins.
Drawing boards, T squares and Set squares.
Indiarubbers.
Pencils.
Pencil compasses, and refills.
12″ rules, boxwood.
Envelopes and notepaper.
Ink, red and black and ink-wells.
Pens.

TIMBER

Basswood.
American Yellow Pine.
Cedar.
Mahogany.
Oak.
Sycamore.
Teak.
American Walnut.
Satin Walnut.

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